California Progress in Energy-Efficient Buildings
The Long View: 1974 – 2030

August 5, 2008

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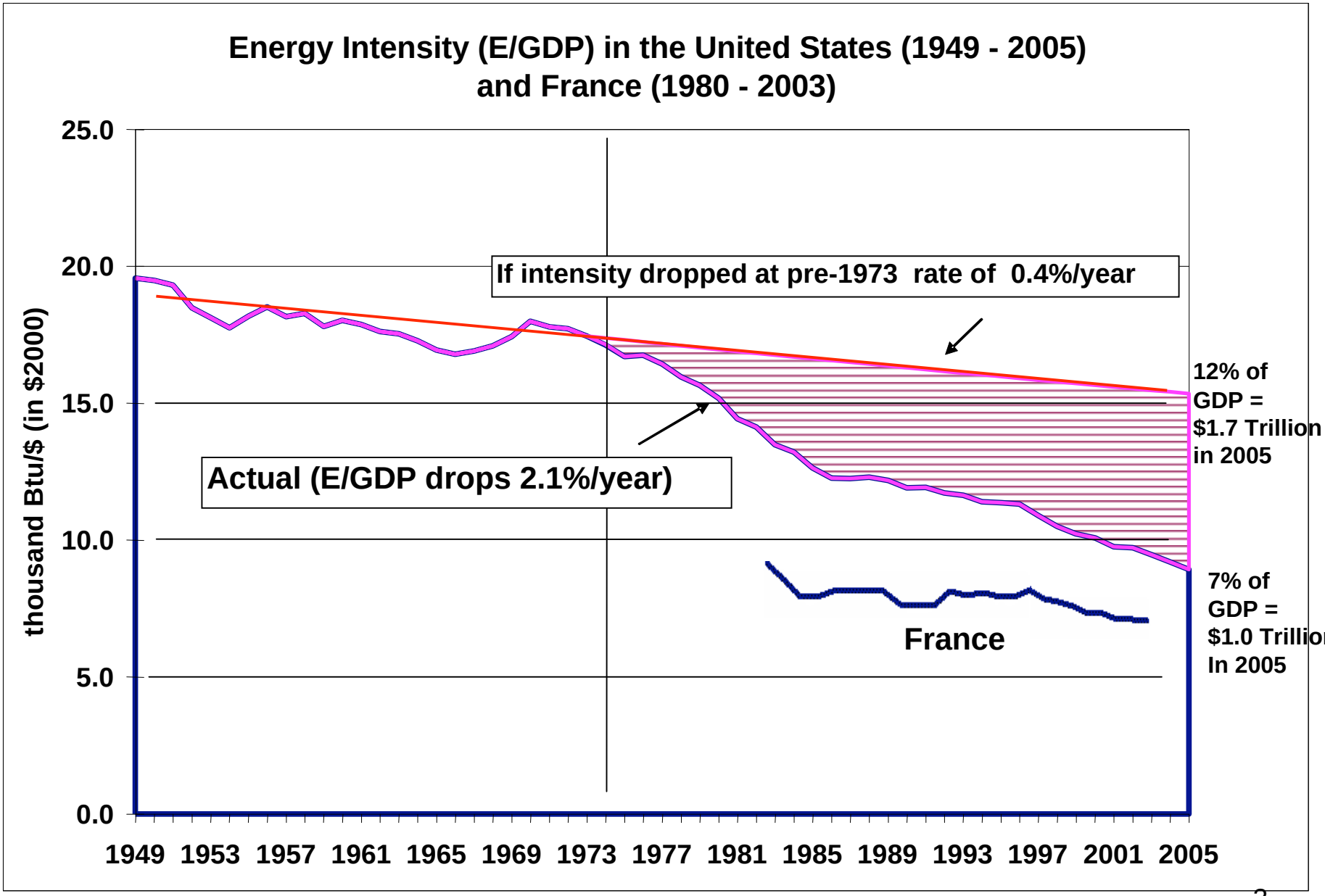
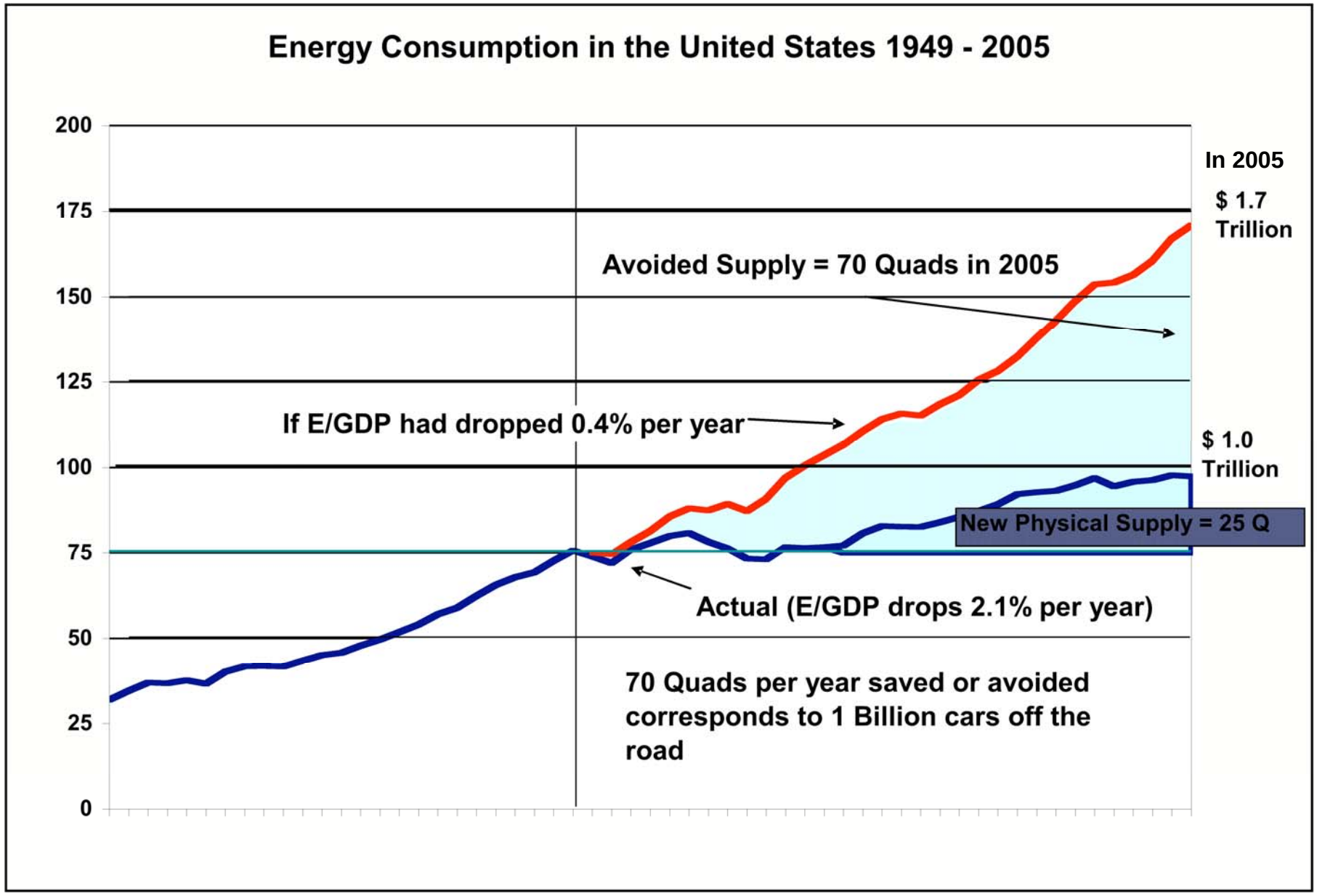
or just Google "Art Rosenfeld"

California Energy Commission Responsibilities

Both Regulation and R&D

- California Building and Appliance Standards
  - Started 1977
  - Updated every few years
- Siting Thermal Power Plants Larger than 50 MW
- Forecasting Supply and Demand (electricity and fuels)
- Research and Development
  - ~ $80 million per year
- California is introducing communicating electric meters and thermostats that are programmable to respond to time-dependent electric tariffs.


Energy Intensity (E/GDP) in the United States (1949 - 2005)
and France (1980 - 2003)
thousand Btu/$ (in $2000)
25.0
20.0
15.0
10.0
5.0
0.0
1949
1953
1957
1961
1965
1969
1973
1977
1981
1985
1989
1993
1997
2001
2005
If intensity dropped at pre-1973 rate of 0.4%/year
Actual (E/GDP drops 2.1%/year)
France
12% of GDP = $1.7 Trillion in 2005
7% of GDP = $1.0 Trillion In 2005


Energy Consumption in the United States 1949 - 2005
200
175
150
125
100
75
50
25
0
In 2005
$ 1.7 Trillion
Avoided Supply = 70 Quads in 2005
If E/GDP had dropped 0.4% per year
$ 1.0 Trillion
New Physical Supply = 25 Q
Actual (E/GDP drops 2.1% per year)
70 Quads per year saved or avoided corresponds to 1 Billion cars off the road

How Much of The Savings Come from Efficiency

- Some examples of estimated savings in 2006 based on 1974 efficiencies minus 2006 efficiencies

	Billion $
Space Heating	**40**
Air Conditioning	**30**
Refrigerators	**15**
Fluorescent Tube Lamps	**5**
Compact Floursecent Lamps	**5**
Total	**95**

- Beginning in 2007 in California, reduction of “vampire” or stand-by losses
  - This will save $10 Billion when finally implemented, nation-wide
- Out of a total **$700 Billion**, a crude summary is that 1/3 is structural, 1/3 is from transportation, and 1/3 from buildings and industry.

Two Energy Agencies in California

- The California Public Utilities Commission (CPUC) was formed in 1890 to regulate natural monopolies, like railroads, and later electric and gas utilities.
- The California Energy Commission (CEC) was formed in 1974 to regulate the environmental side of energy production and use.
- Now the two agencies work very closely, particularly to delay climate change.
- The Investor-Owned Utilities, under the guidance of the CPUC, spend “Public Goods Charge” money (rate-payer money) to do everything they can that is cost effective to beat existing standards.
- The Publicly-Owned utilities (20% of the power), under loose supervision by the CEC, do the same.

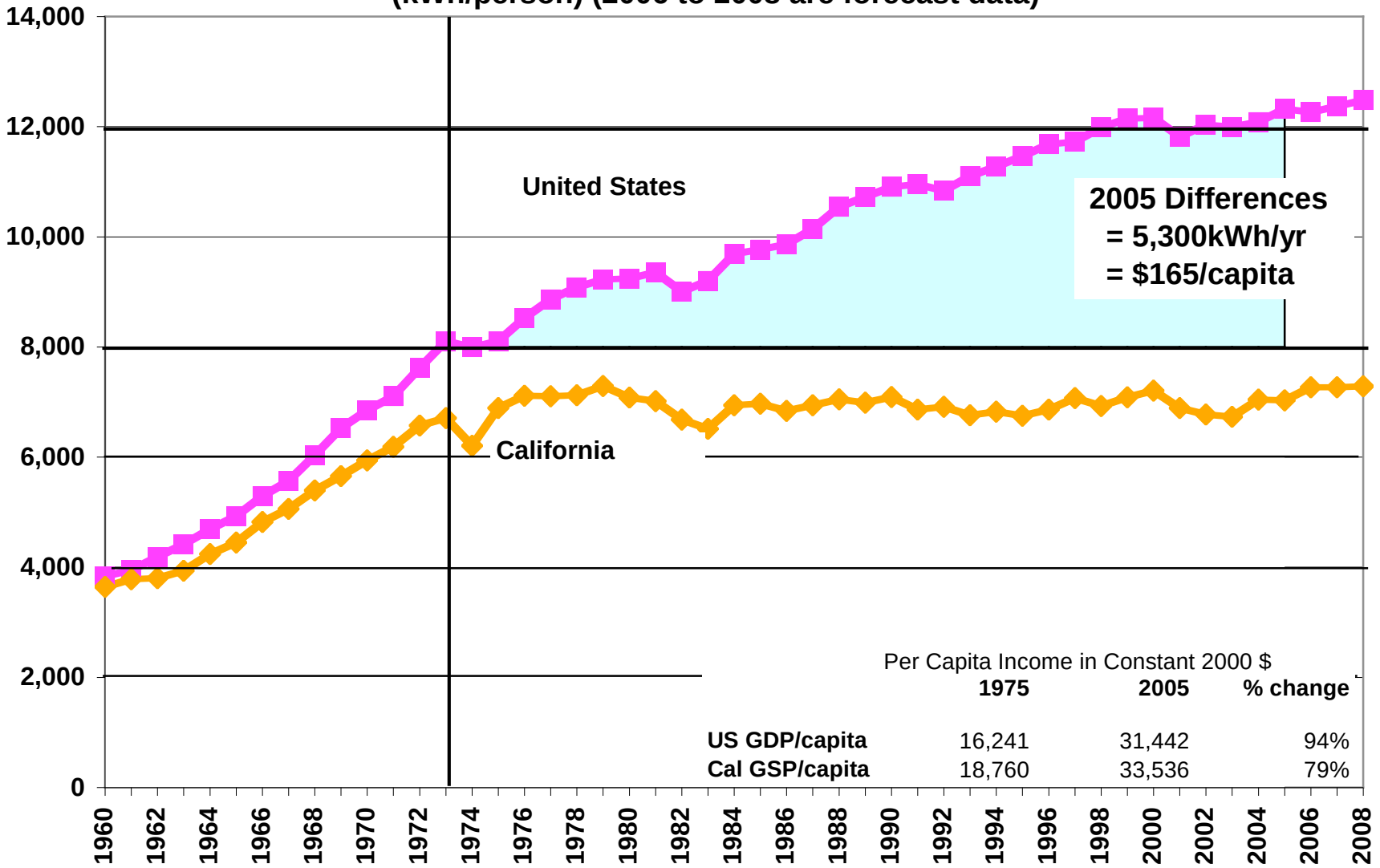
California's Energy Action Plan

- California's Energy Agencies first adopted an Energy Action Plan in 2003. Central to this is the State's preferred "Loading Order" for resource expansion.

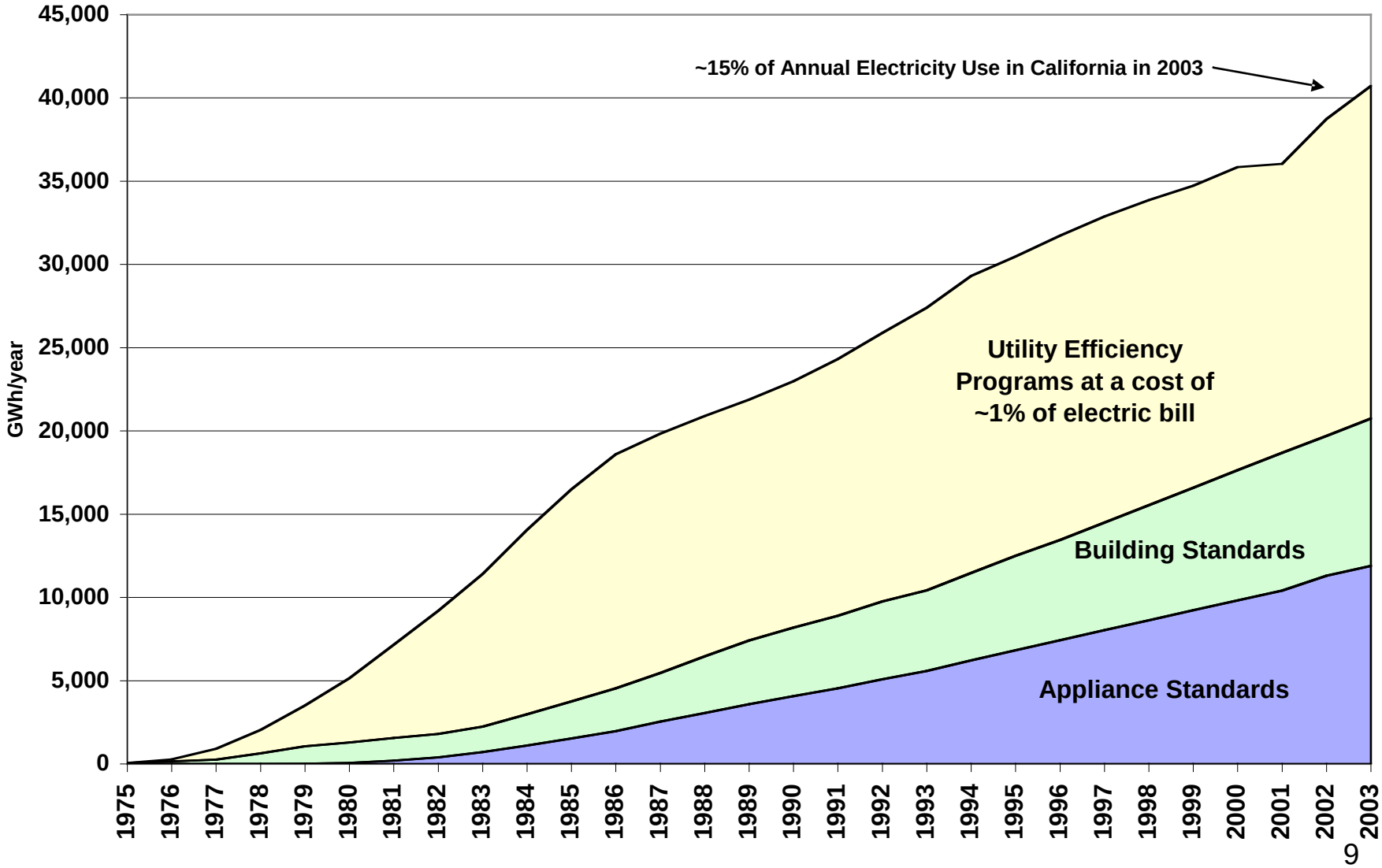
- 1. Energy efficiency and Demand Response
- 2. Renewable Generation,
- 3. Increased development of affordable & reliable conventional generation
- 4. Transmission expansion to support all of California's energy goals.

- The Energy Action Plan has been updated since 2003 and provides overall policy direction to the various state agencies involved with the energy sectors

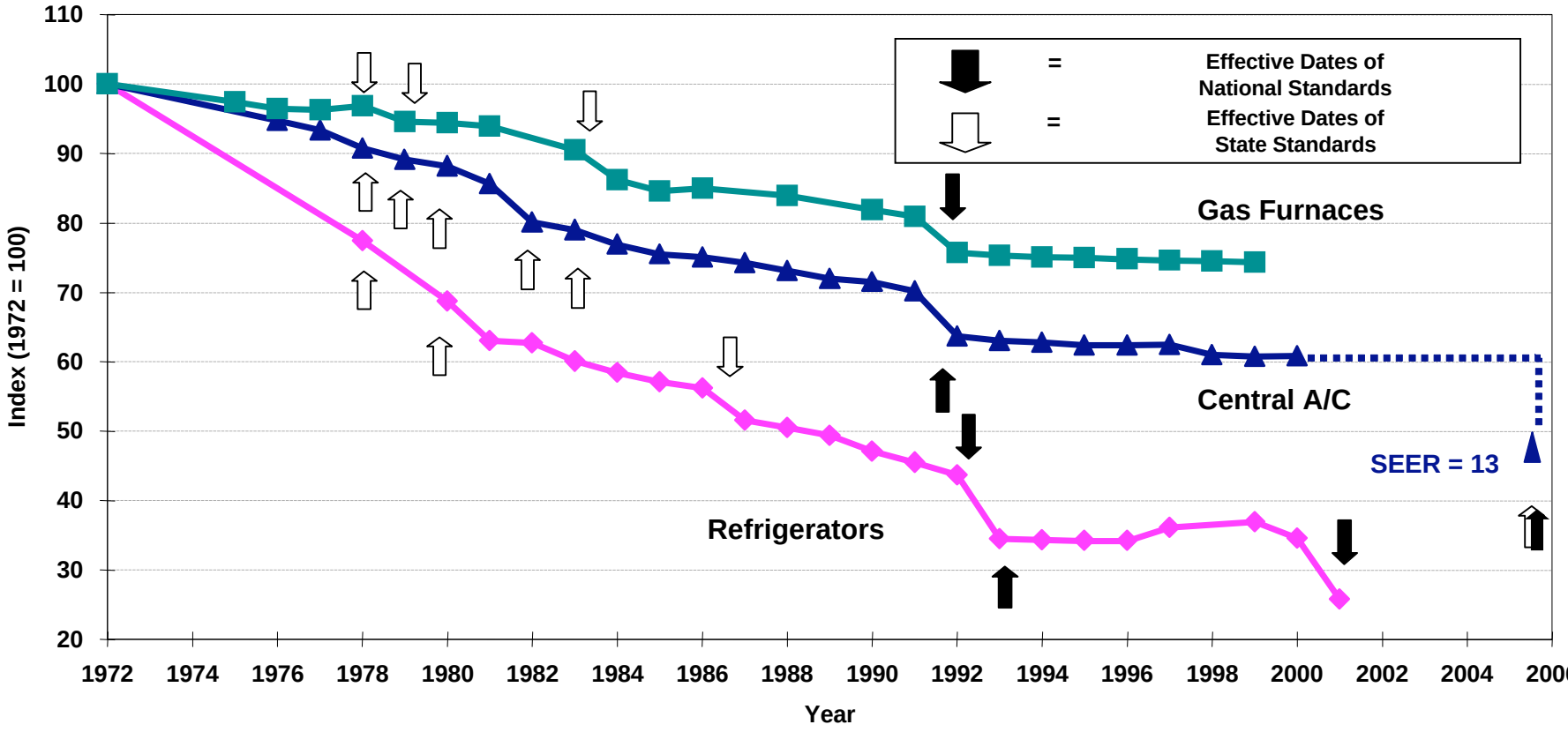
Per Capita Electricity Sales (not including self-generation) (kWh/person) (2006 to 2008 are forecast data)



Annual Energy Savings from Efficiency Programs and Standards



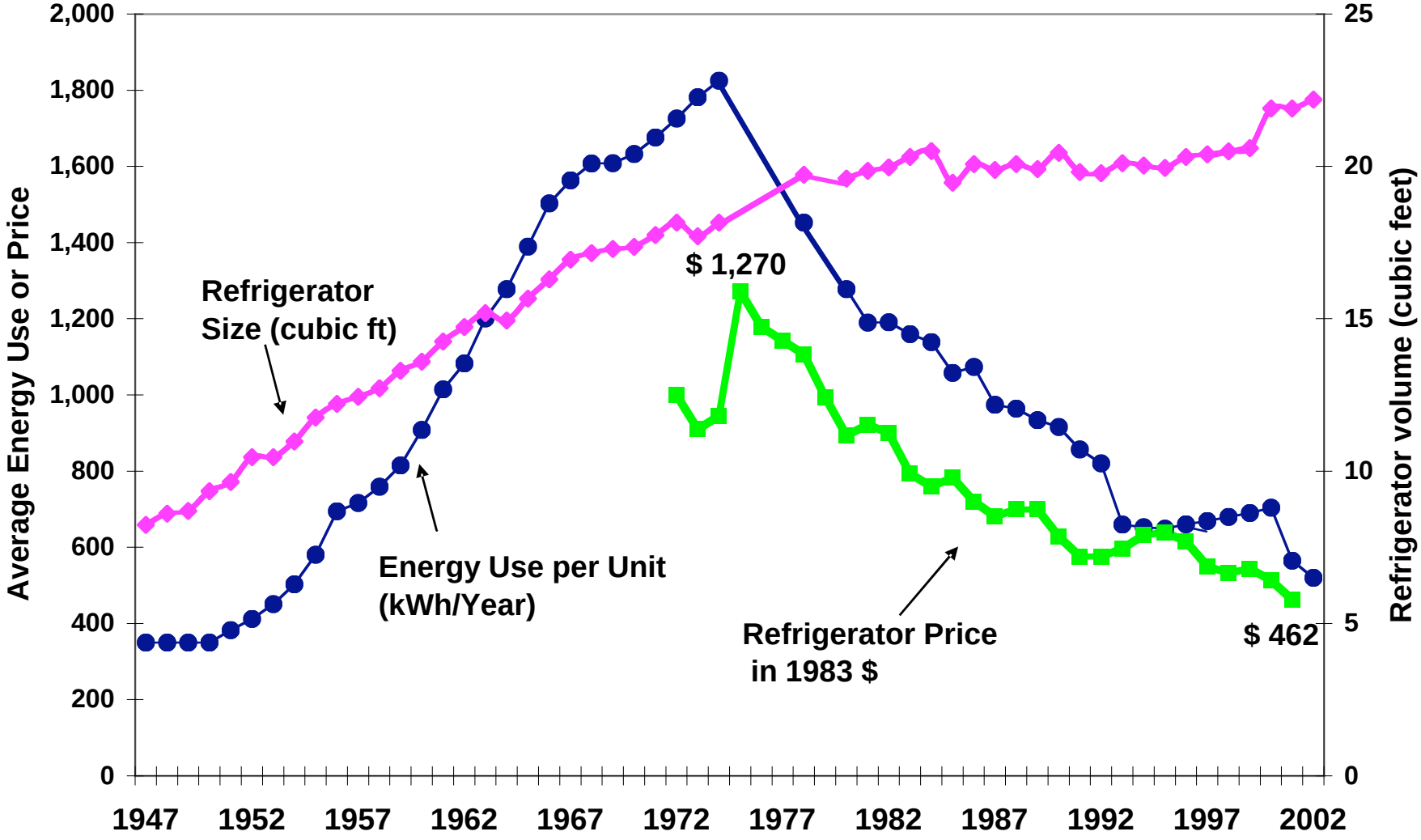
Impact of Standards on Efficiency of 3 Appliances



Source: S. Nadel, ACEEE,

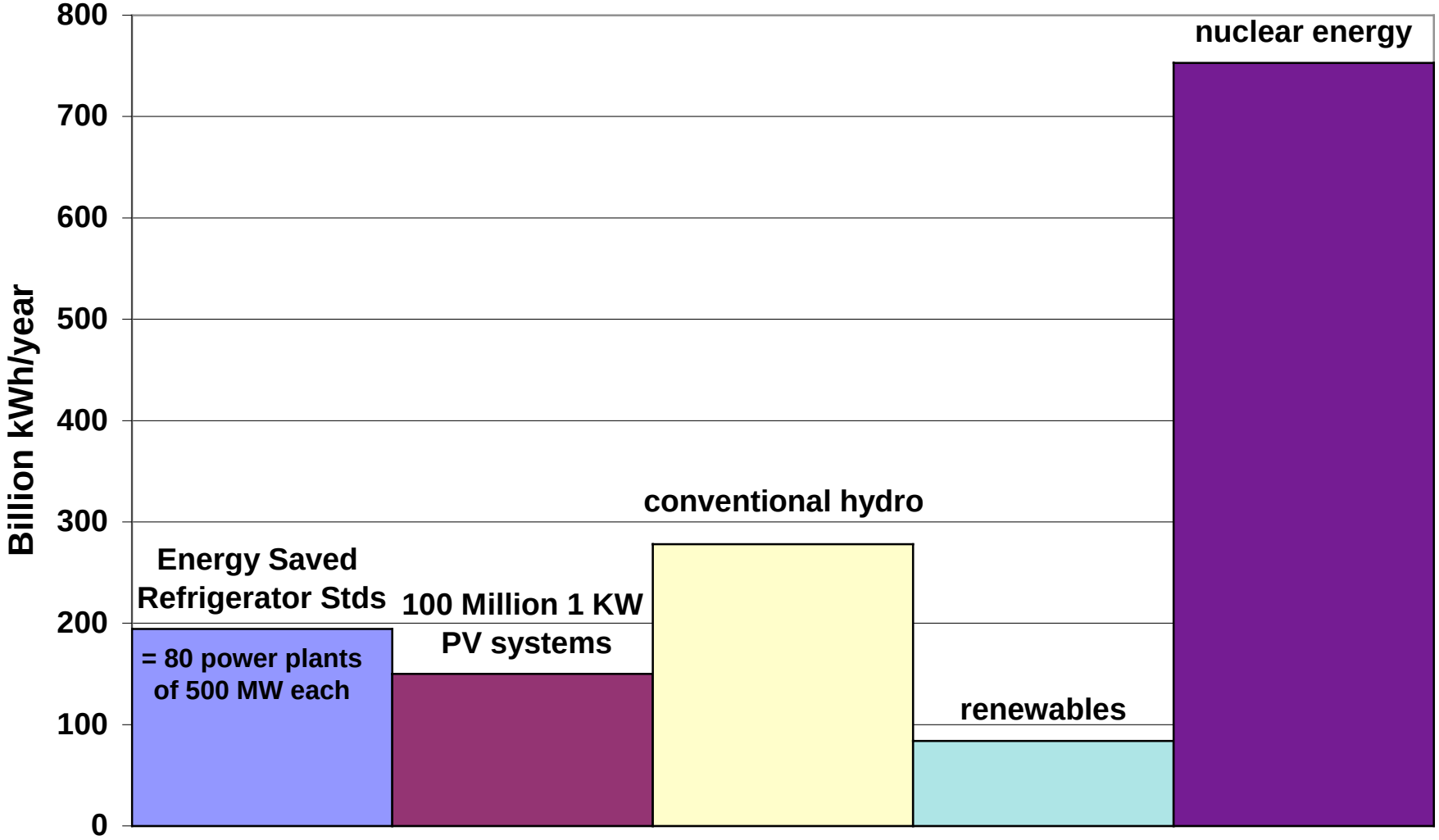
in ECEEE 2003 Summer Study, www.eceee.org

New United States Refrigerator Use v. Time and Retail Prices



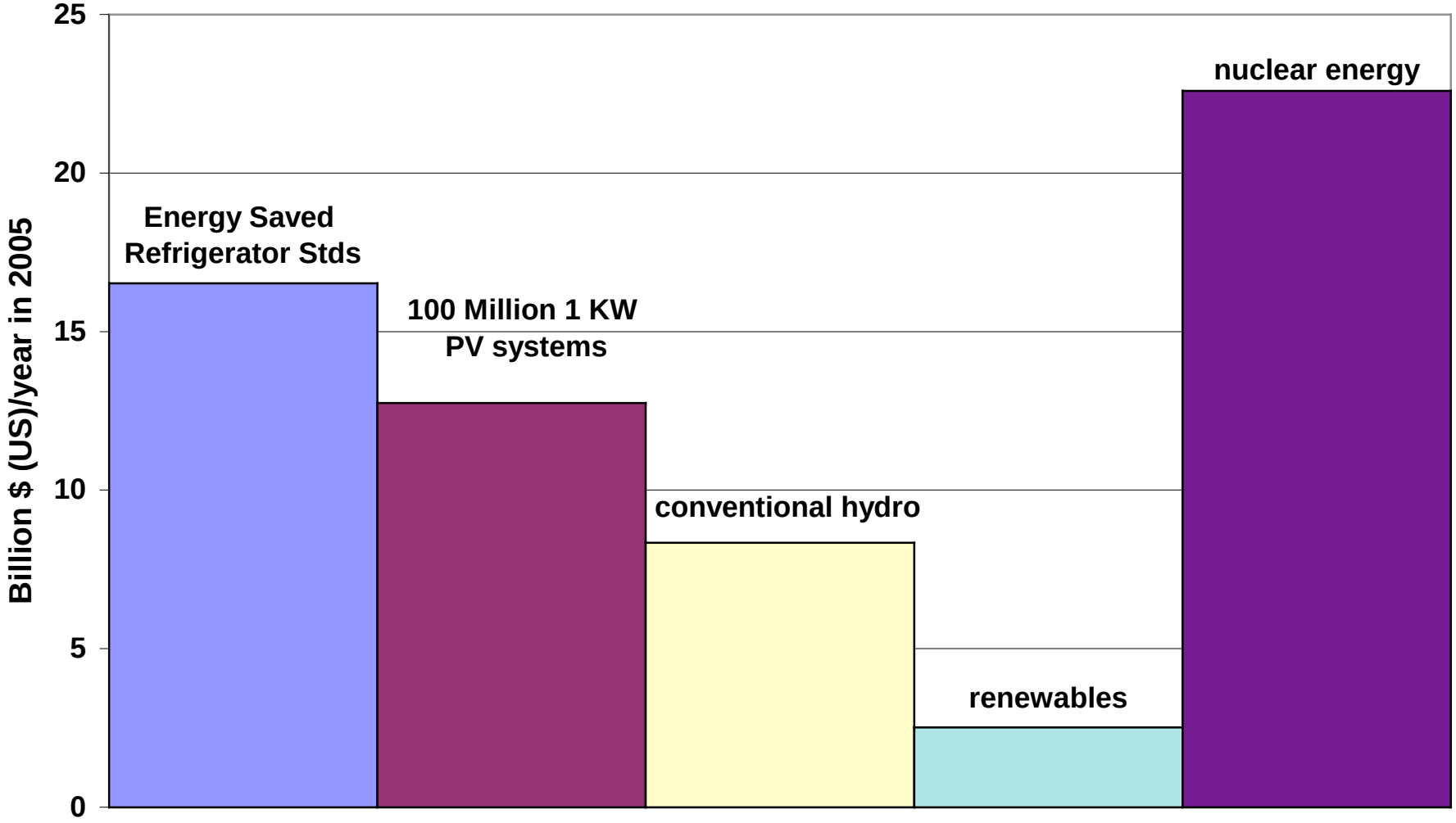
Source: David Goldstein

Annual Energy Saved vs. Several Sources of Supply In the United States

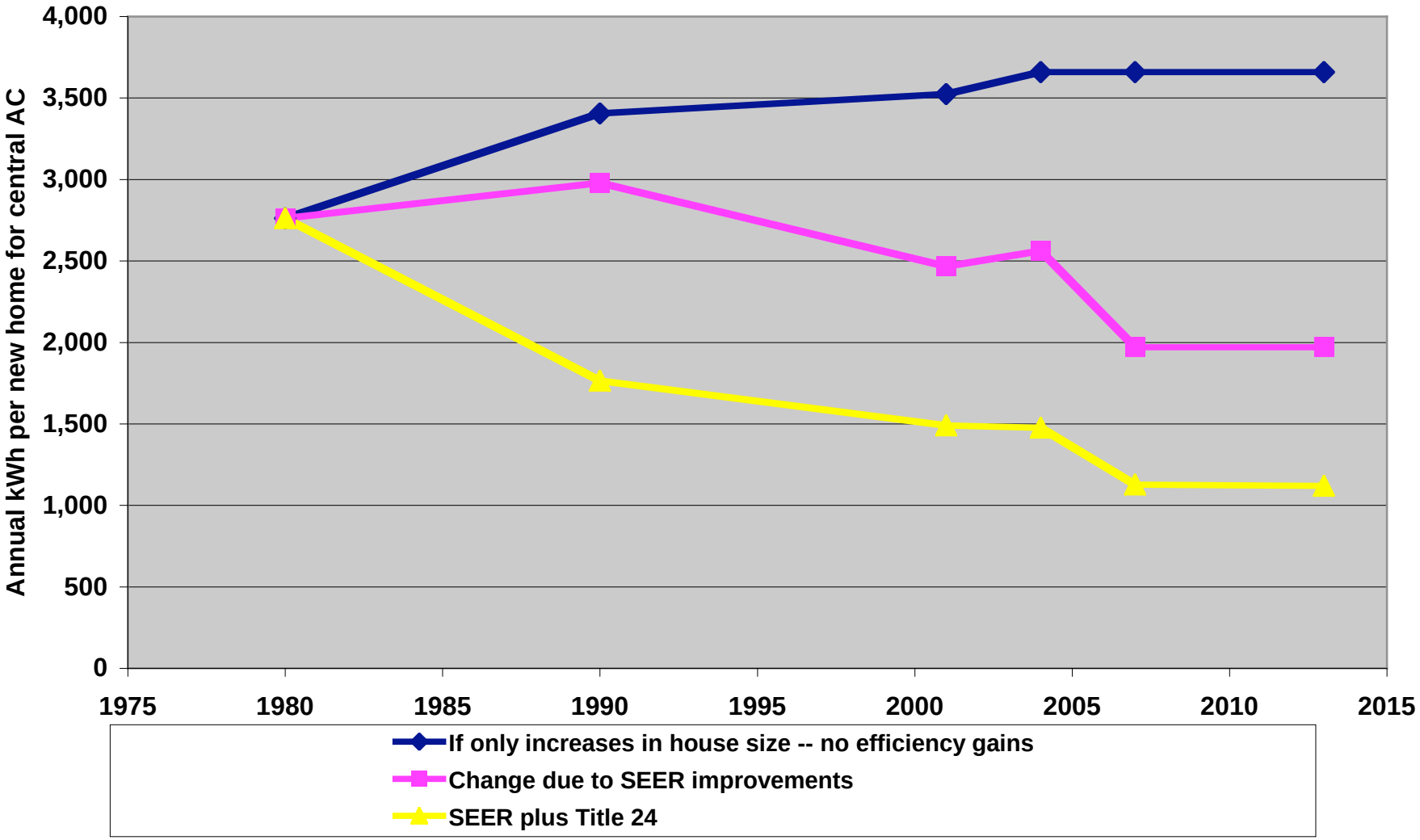


In the United States

Value of Energy to be Saved (at 8.5 cents/kWh, retail price) vs. Several Sources of Supply in 2005 (at 3 cents/kWh, wholesale price)

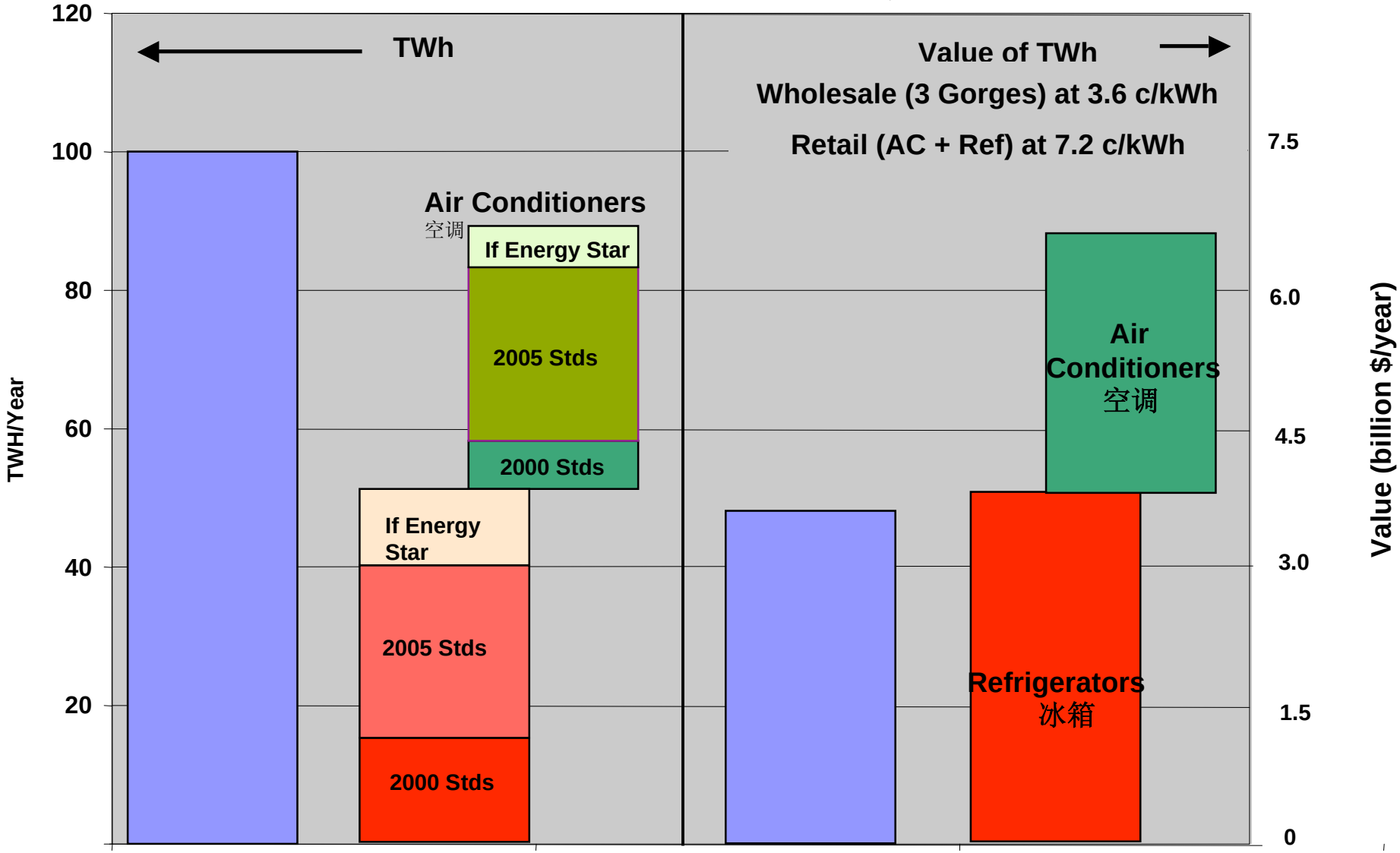


Air Conditioning Energy Use in Single Family Homes in PG&E
The effect of AC Standards (SEER) and Title 24 standards



Comparison of 3 Gorges to Refrigerator and AC Efficiency Improvements

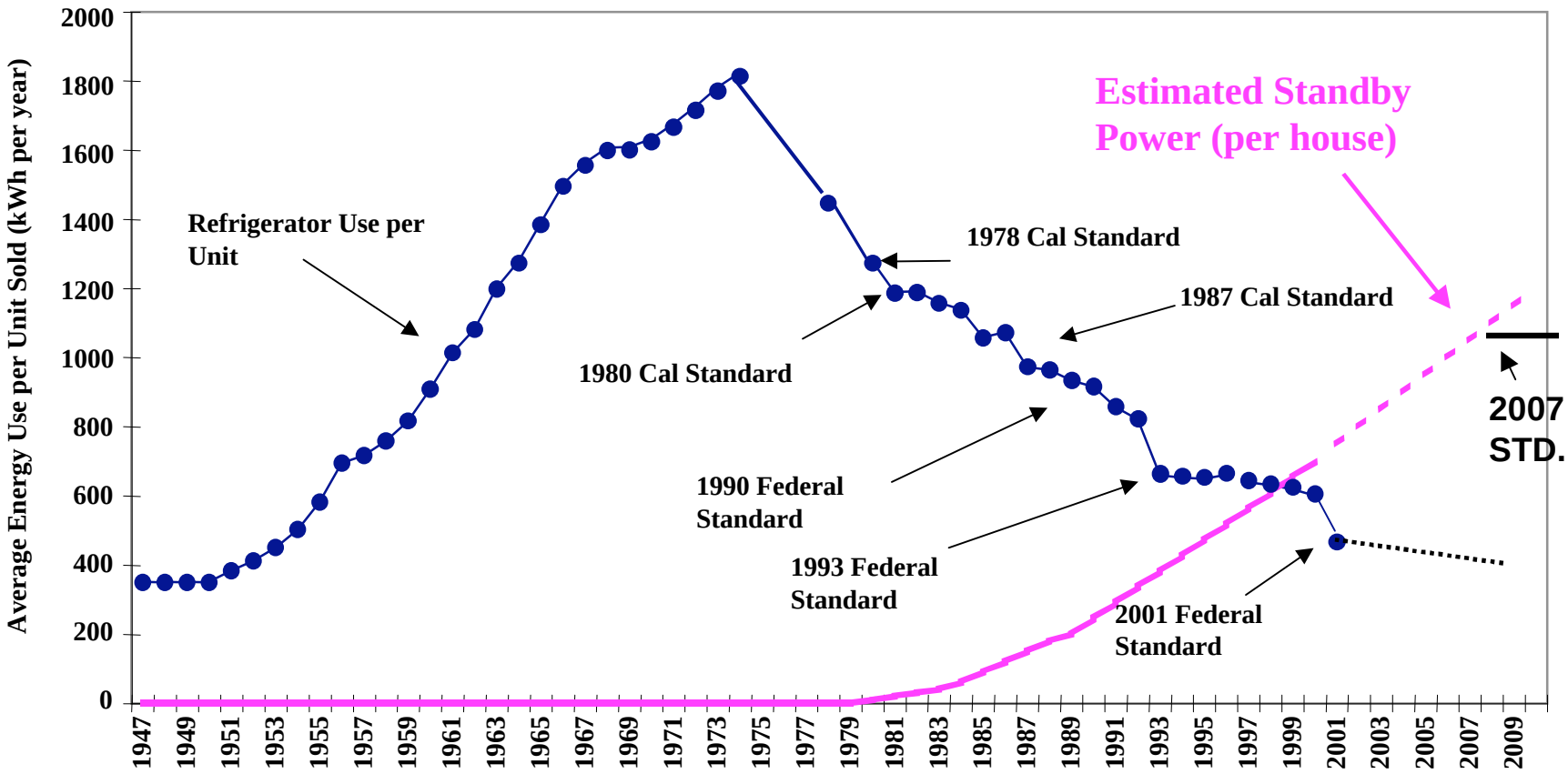
三峡电量与电冰箱、空调能效对比



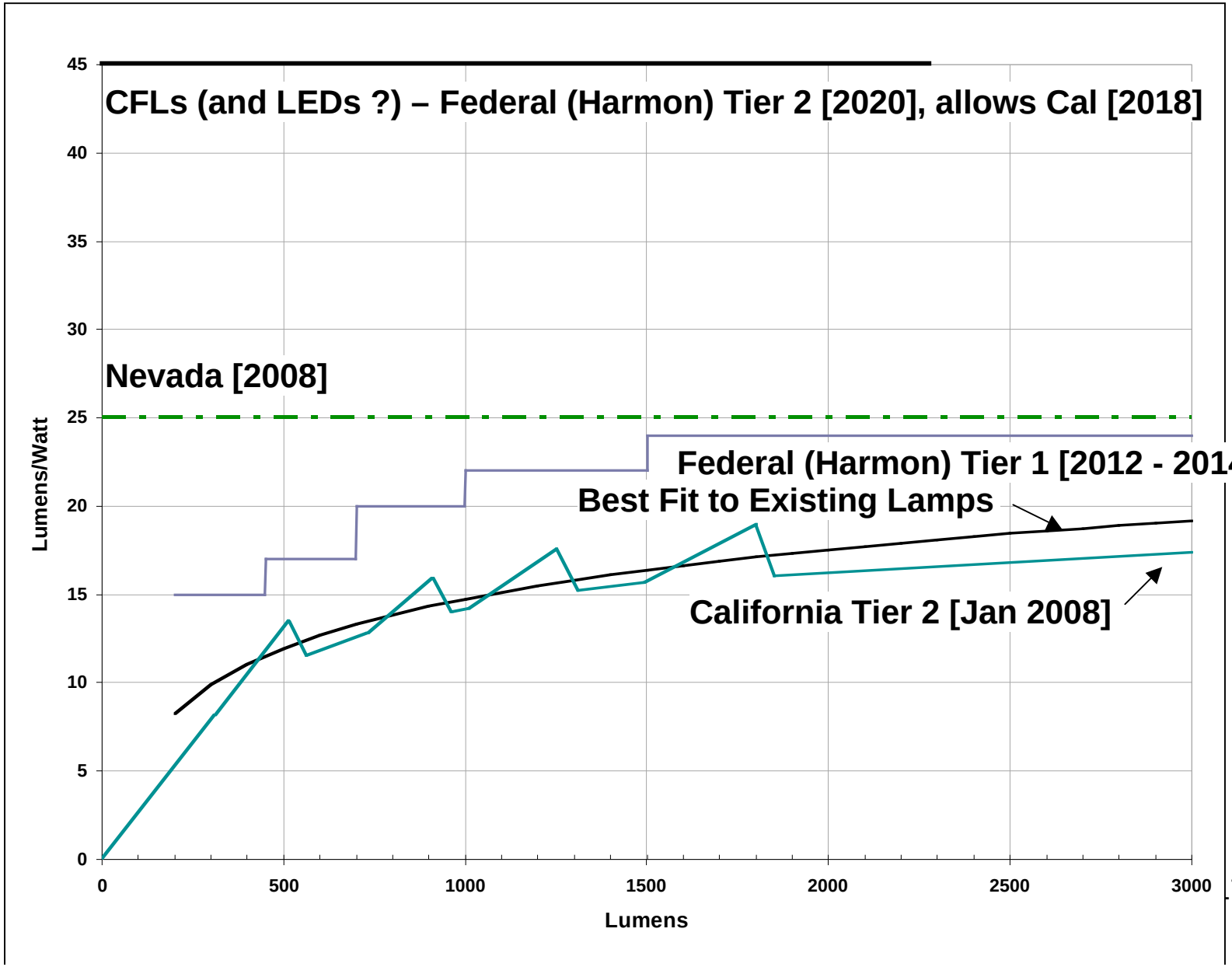
Savings calculated 10 years after standard takes effect. Calculations provided by David Fridley, LBNL

标准生效后，10年节约电量

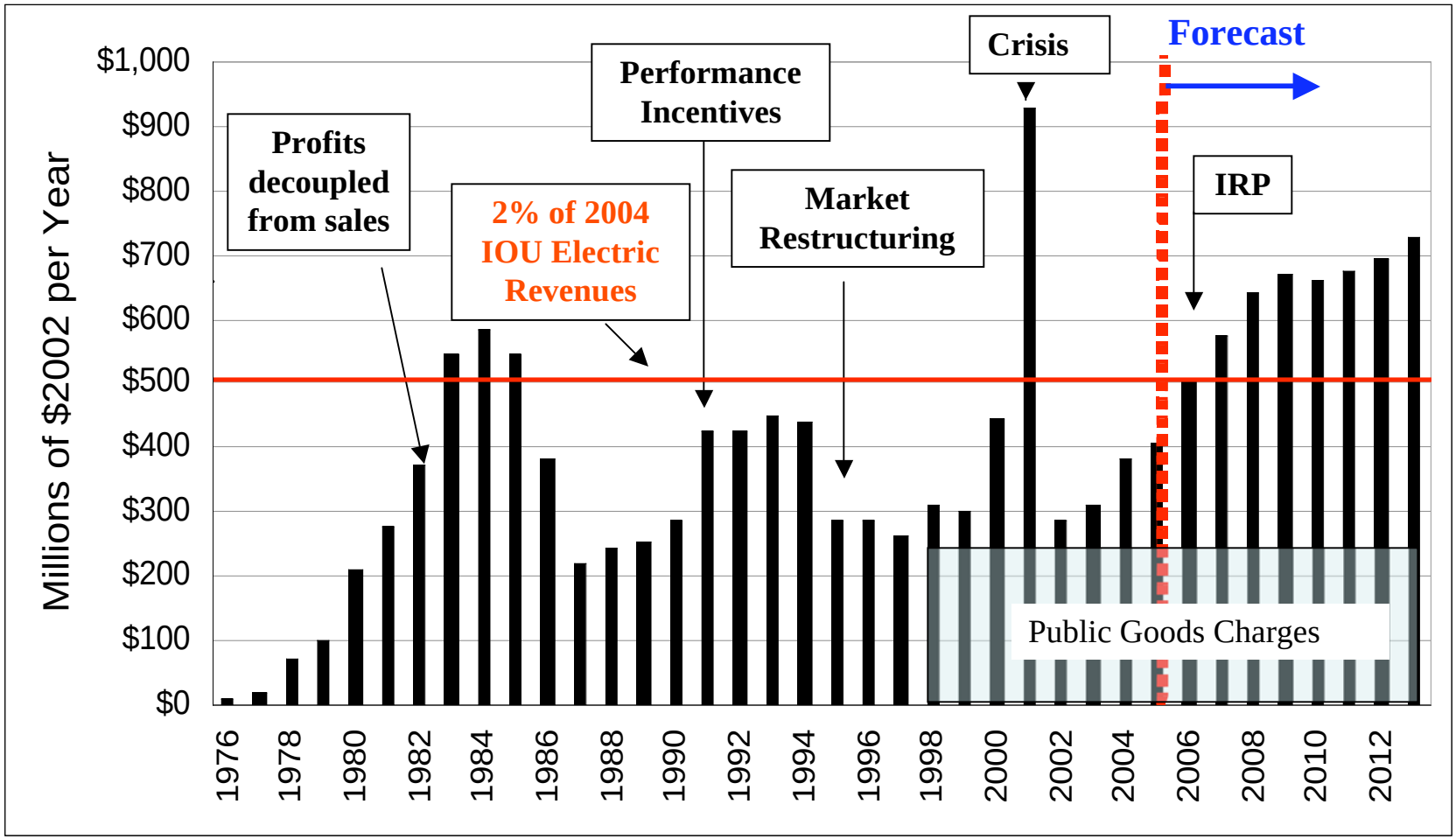
United States Refrigerator Use, repeated, to compare with Estimated Household Standby Use v. Time



Improving and Phasing-Out Incandescent Lamps

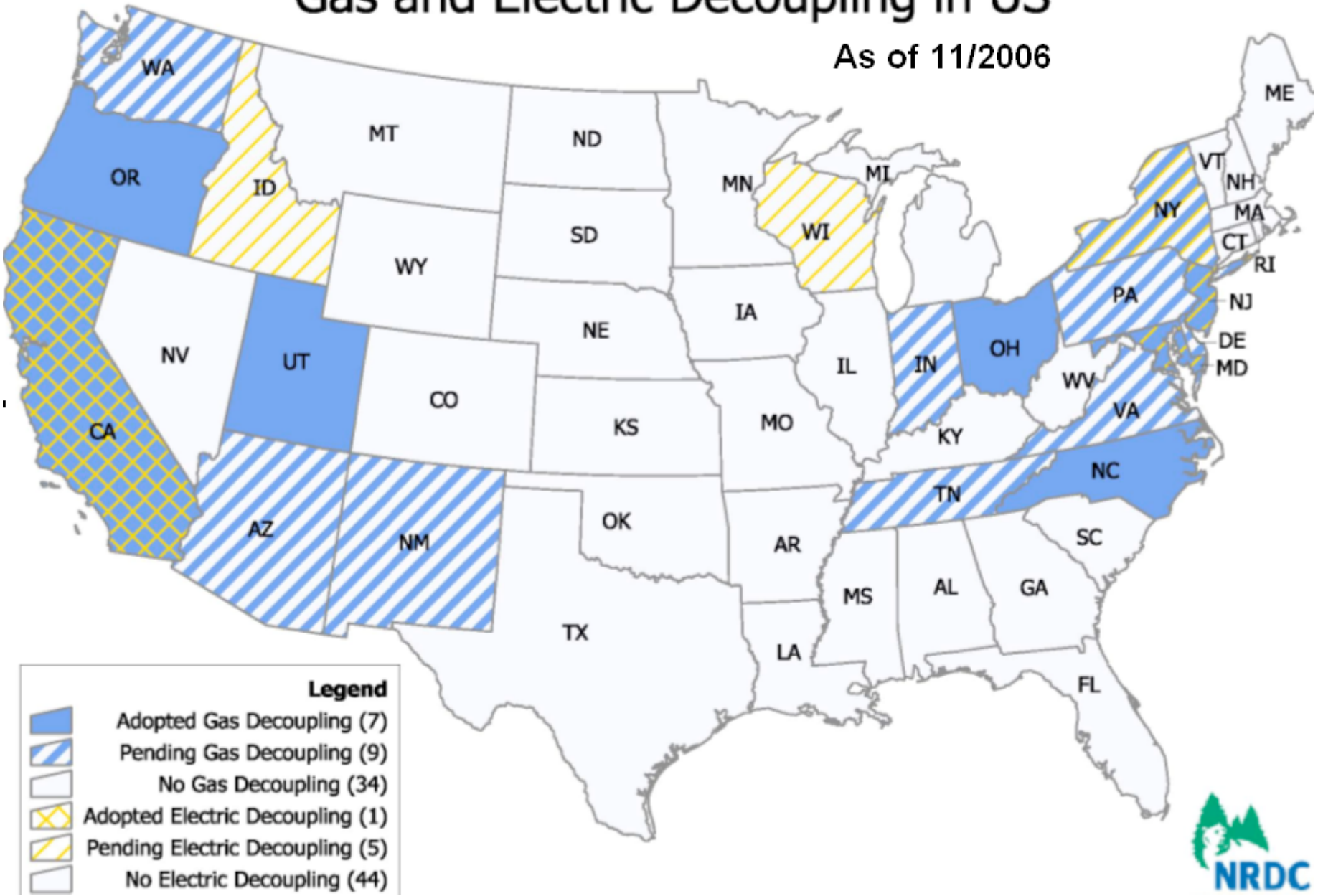


California IOU's Investment in Energy Efficiency



Gas and Electric Decoupling in US

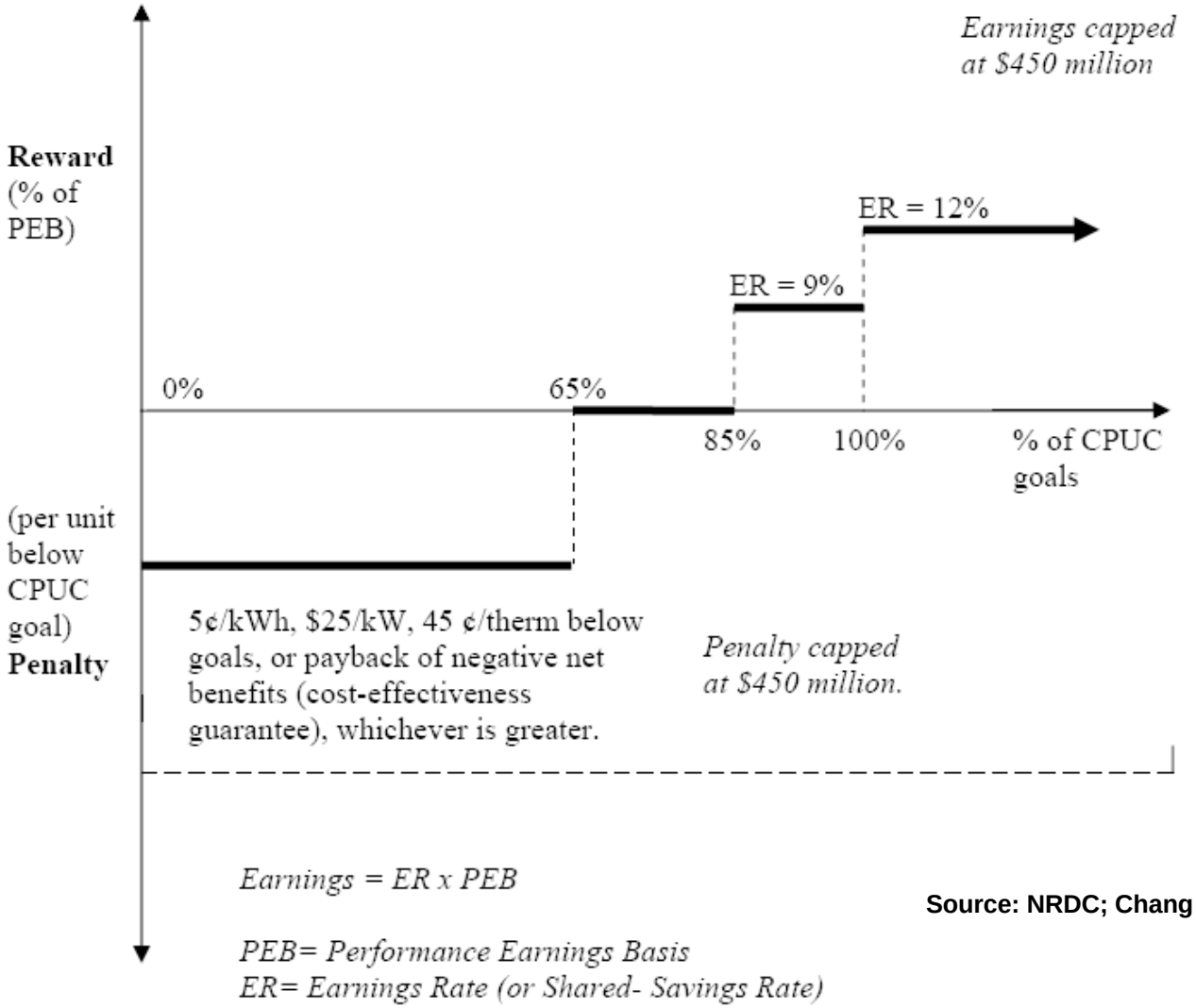
As of 11/2006



NRDC

Energy Efficiency Incentive Mechanism Earnings/Penalty Curve
(D.07-09-043, p. 8)

"Decoupling Plus"



Source: NRDC; Chang and Wang, 9/26/2007

Part 2
Cool Urban Surfaces and Global Warming

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Lawrence Berkeley National Laboratory

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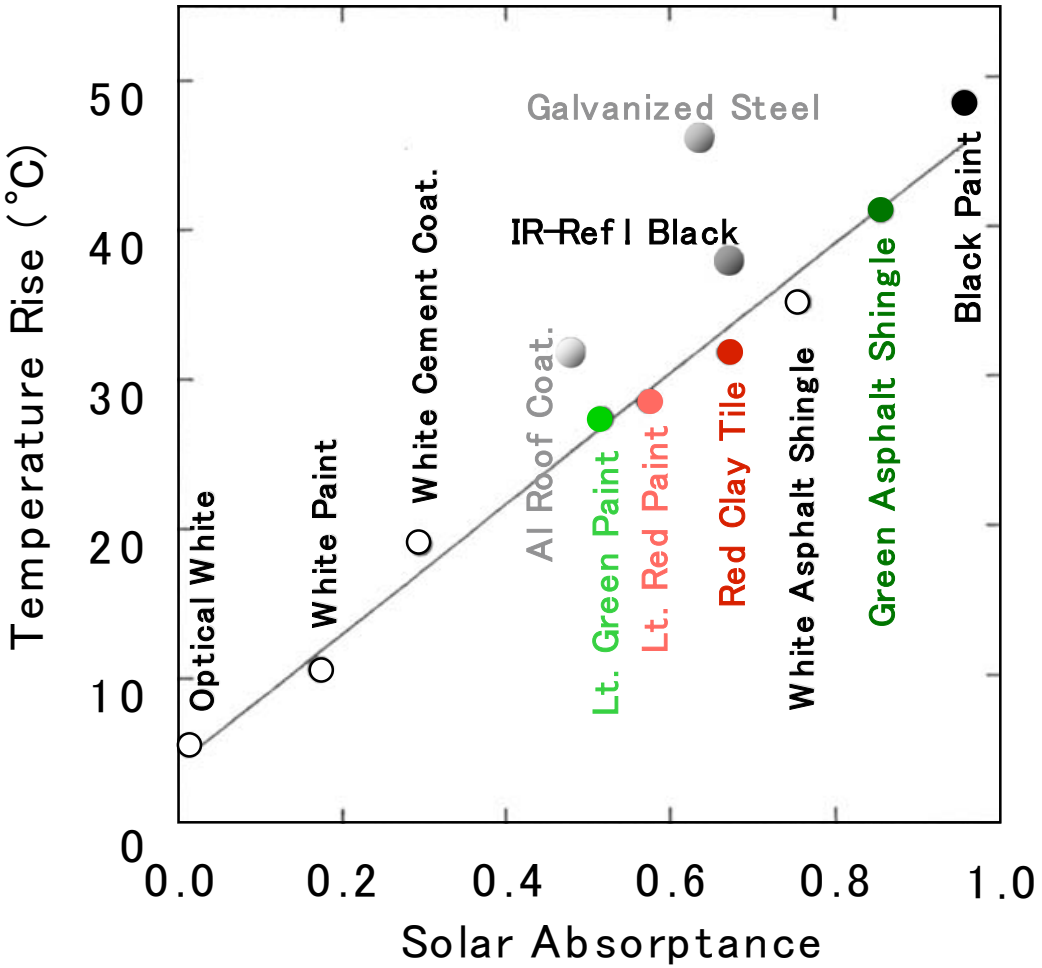
Email: H_Akbari@LBL.gov
http:HeatIsland.LBL.gov

International Workshop on Countermeasures to Urban Heat Islands August 3 - 4, 2006; Tokyo, Japan

Temperature Rise of Various Materials in Sunlight



Direct and Indirect Effects of Light-Colored Surfaces

- **Direct Effect**
  - **Light-colored roofs** reflect solar radiation, reduce air-conditioning use
- **Indirect Effect**
  - Light-colored surfaces in a neighborhood alter surface energy balance; result in lower ambient temperature

and in Santorini, Greece

Cool Roof Technologies

Old

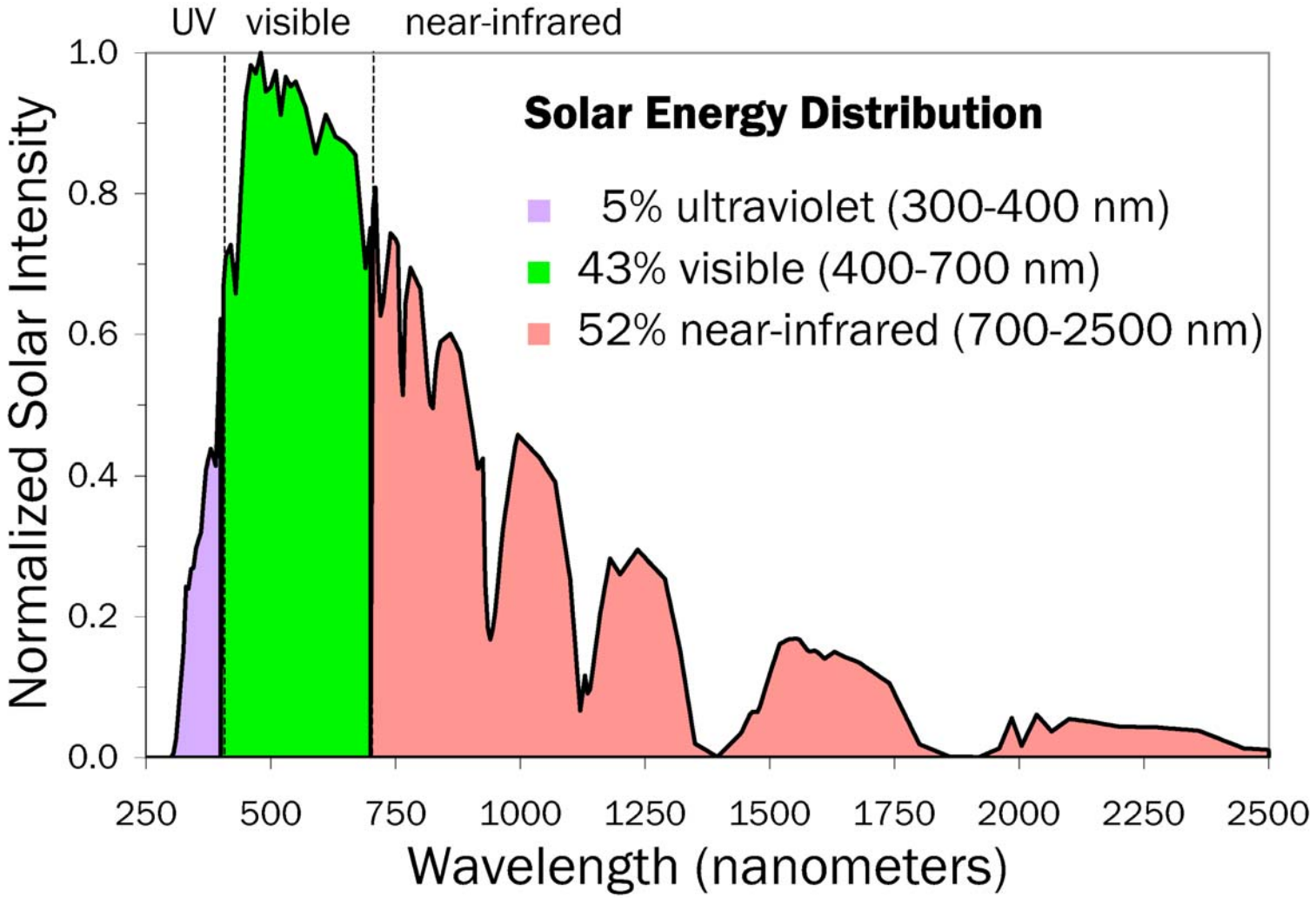
flat, white

pitched, white

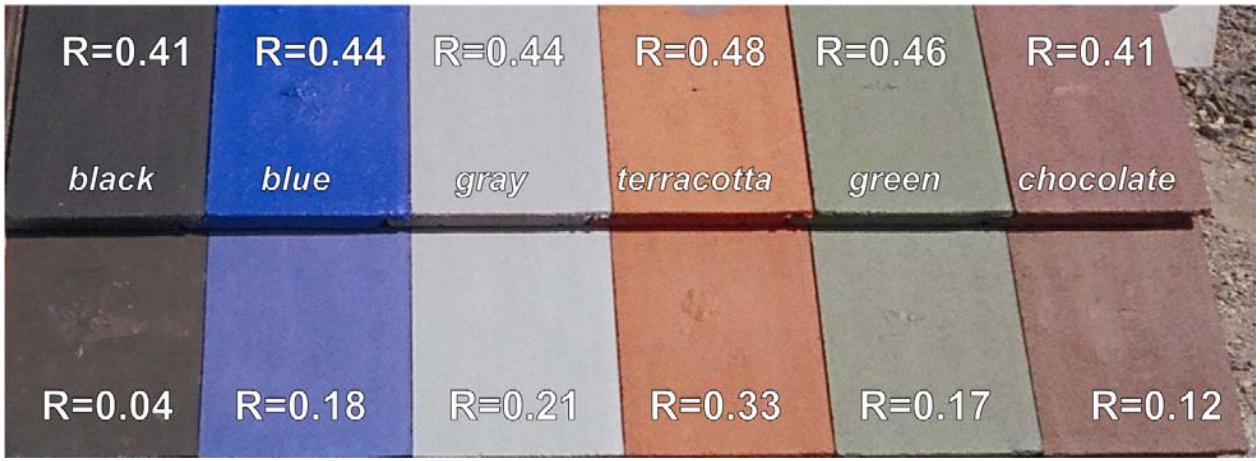
New

pitched, cool & colored

Cool Colors Reflect Invisible Near-Infrared Sunlight



Cool and Standard Color-Matched Concrete Tiles



Courtesy American Rooftile Coatings

cool

standard

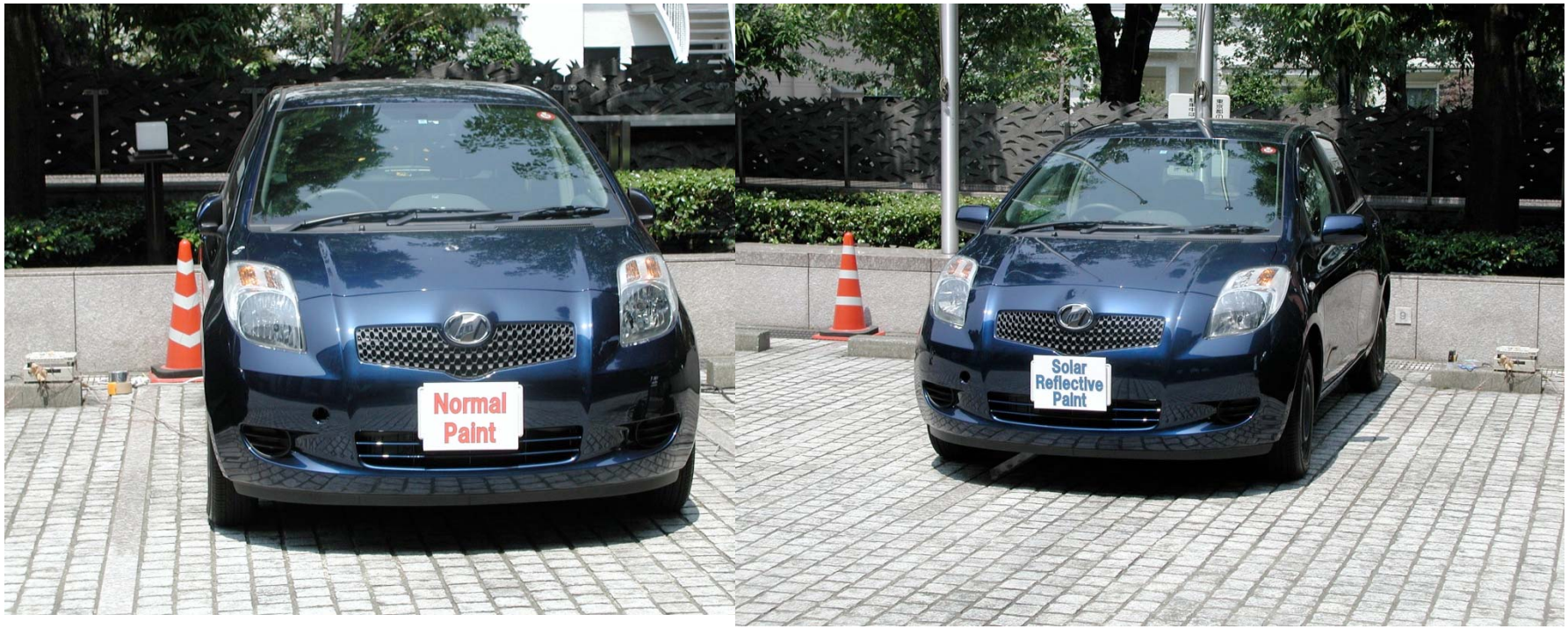
ΔR=0.37 **ΔR=0.26** **ΔR=0.23** **ΔR=0.15** **ΔR=0.29** **ΔR=0.29**

- Can increase solar reflectance by up to 0.5
- Gain greatest for dark colors

Cool Roofs Standards

- Building standards for reflective roofs
  - American Society of Heating and Air-conditioning Engineers (ASHRAE): New commercial and residential buildings
  - **Many states: California, Georgia, Florida, Hawaii, …**
- Air quality standards (qualitative but not quantitative credit)
  - South Coast AQMD
  - S.F. Bay Area AQMD
  - EPA's SIP (State Implementation Plans)

From Cool Color Roofs to Cool Color Cars



- **Toyota experiment (surface temperature 18F cooler)**
- **Ford, BMW, and Fiat are also working on the technology**

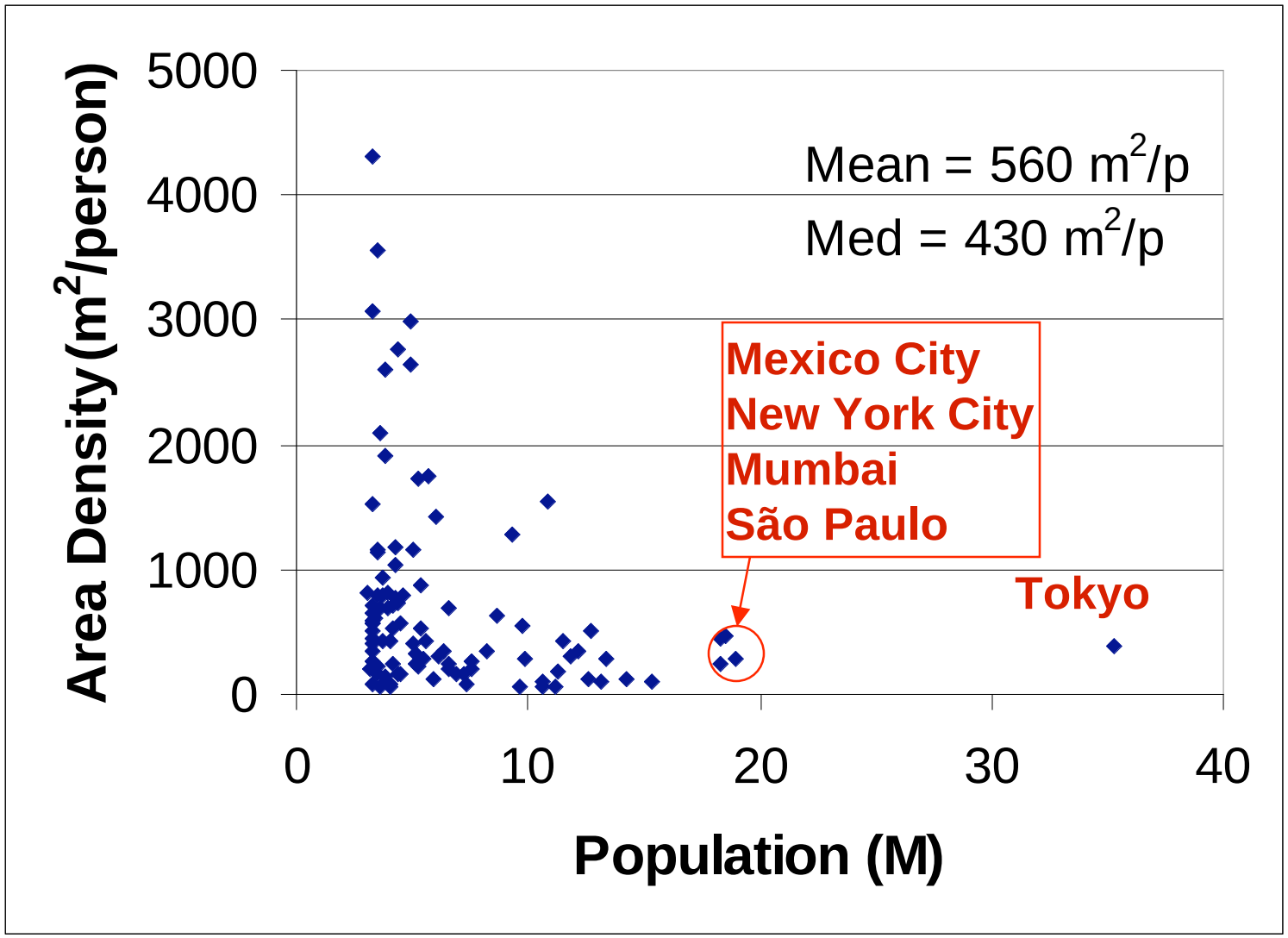
Cool Surfaces Also Delay Global Warming
"White Washing Our Green House"

- Forthcoming:"Global Cooling: Increasing Worldwide Global Albedos" Hashem Akbari, Surabi Menon, Arthur Rosenfeld, submitted to Journal of Climatic Change (2008).

- Conclude that cool roofs and pavements, worldwide, would offset 40 Gt of CO2, which is the same as one years production today !

- The 40 GtCO2 could be achieved over say 20 years, at 2 GtCO2 per year.

100 Largest Cities have 670 M People



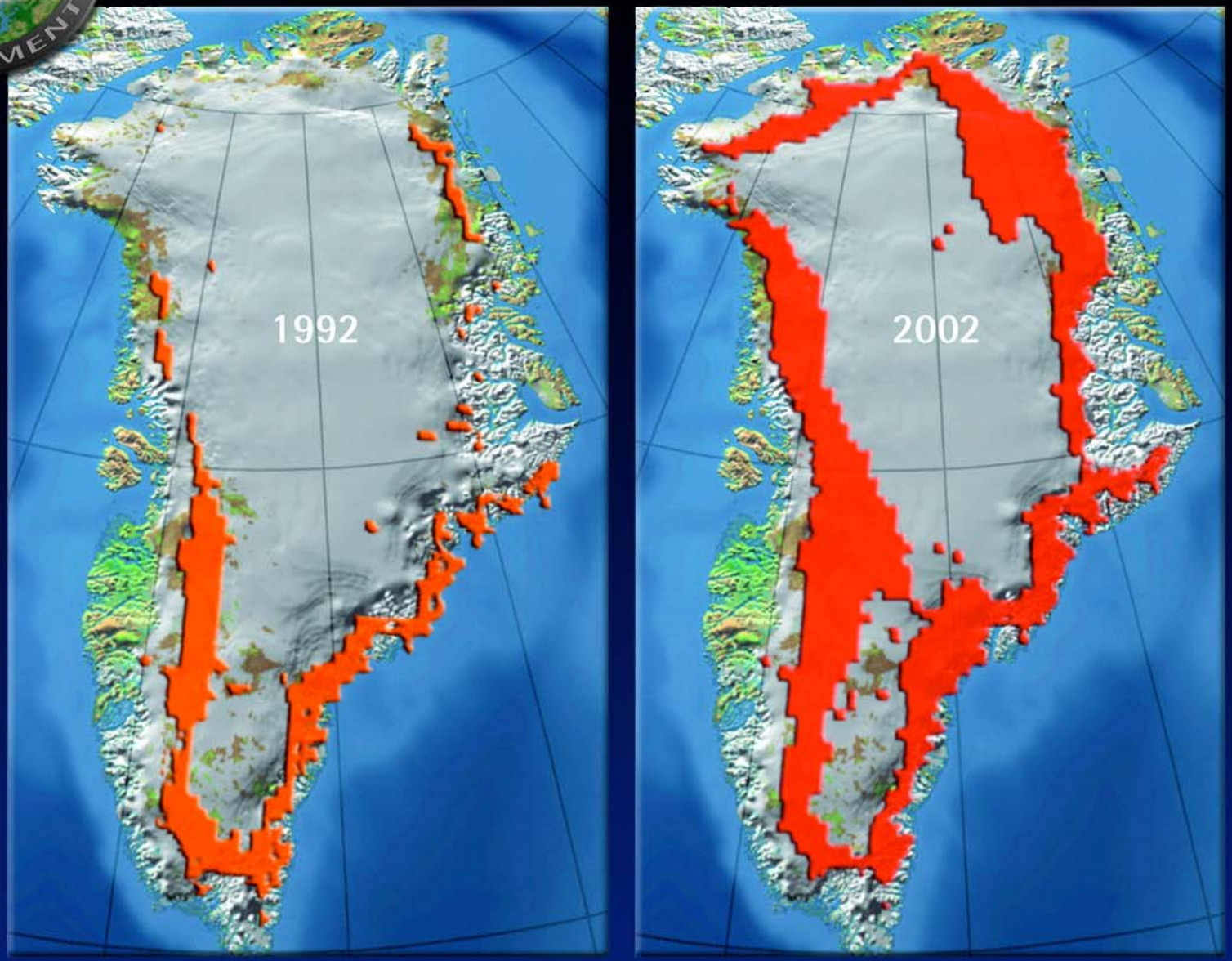
Dense Urban Areas are 1% of Land

- Area of the Earth = 511×10^{12} m^2
- Land Area (29%) = 148×10^{12} m^2 [1]
- Area of the 100 largest cities = 0.38×10^{12} m^2 = 0.26% of Land Area for 670 M people
- Assuming 3B live in urban area, urban areas = [3000/670] x 0.26% = 1.2% of land
- But smaller cities have lower population density, hence, urban areas = 2% of land
- Dense, developed urban areas only 1% of land [2]
- **1% of land is 1.5 x 10^12 m2 = area of a square of side s.**

  s = 1200 km or 750 miles on a side. Roughly the area of the remaining Greenland Ice Cap (see next slide)

IMPACTS OF A WARMING ARCTIC

Greenland Ice Sheet Melt Extent



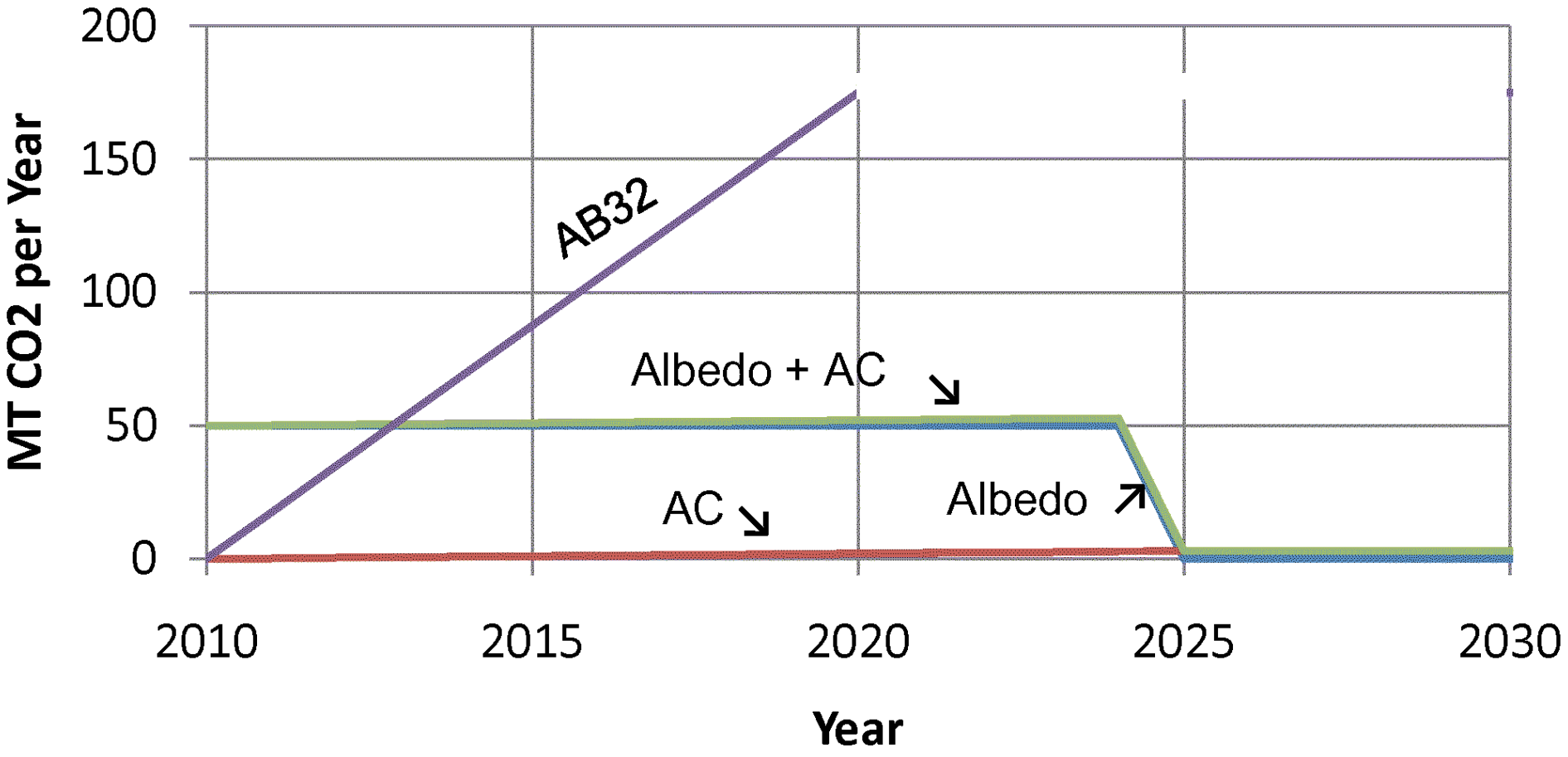
Cooler cities as a mirror

- Mirror Area = 1.5×10^{12} m^2 [5] *(0.1/0.7)[δ albedo of cities/ δ albedo of mirror]
  = 0.2×10^{12} m^2 = 200,000 km^2 {This is equivalent to an square of 460 km on the side}
  = 10% of Greenland = 50% of California

Equivalent Value of Avoided CO_2

- CO_2 currently trade at ~$25/ton
- 40Gt worth $1000 Billion = $1 Trillion for changing albedo of roofs and paved surface
- Cooler roofs alone worth $500 B
- Cooler roofs also save air conditioning (and provide comfort) worth ten times more
- Let developed countries offer $1 million per large city in a developing country, to trigger a cool roof/pavement program in that city

California cool urban surfaces and AB32



Reducing U.S. Greenhouse Gas Emissions: *How Much at What Cost?*

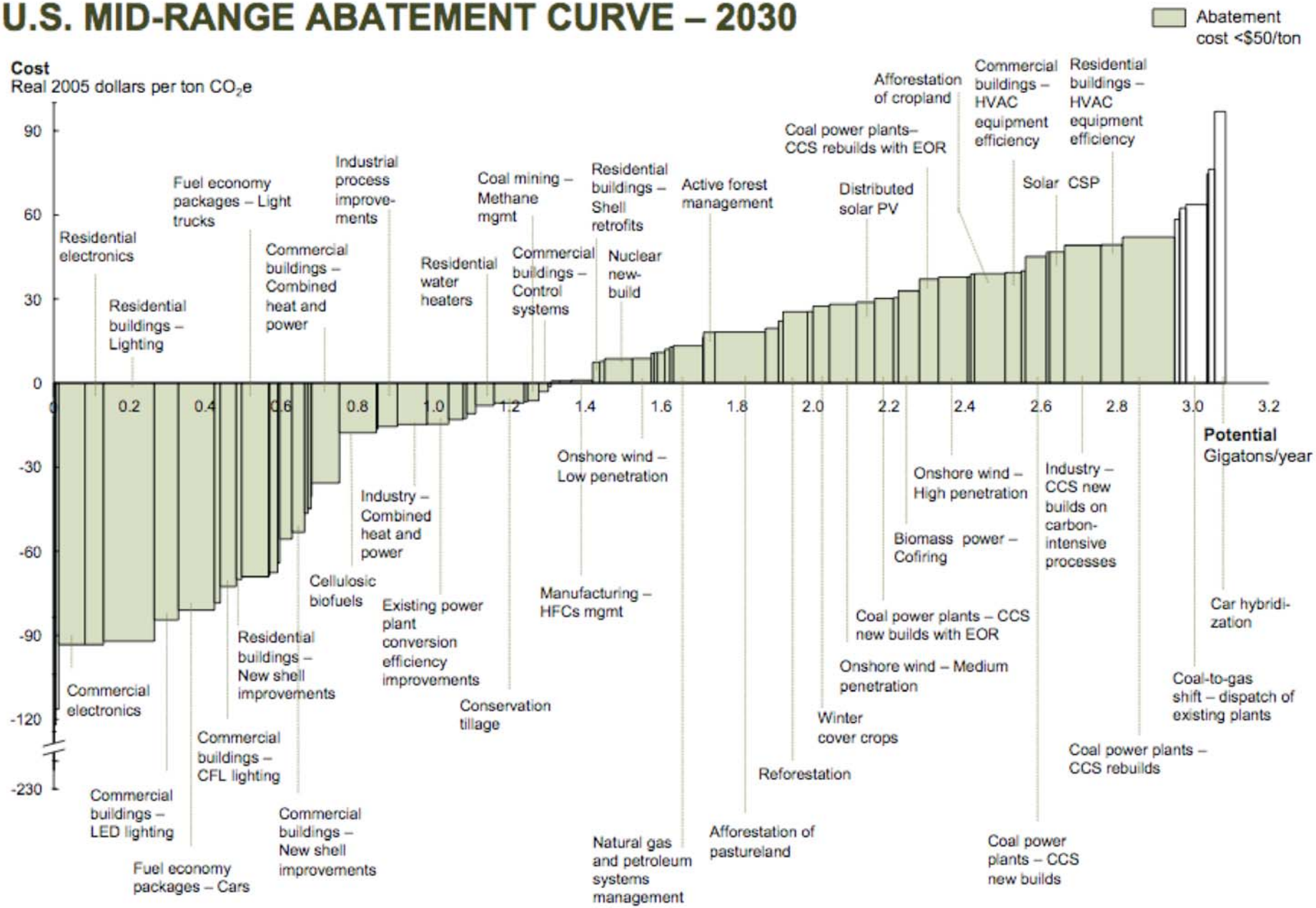
US Greenhouse Gas Abatement Mapping Initiative

December 12, 2007

McKinsey&Company

Exhibit B

U.S. MID-RANGE ABATEMENT CURVE – 2030



Source: McKinsey analysis

McKinsey CO2 Abatement Curves

- McKinsey provides the first graph we've seen that offers a balanced graphical comparison of
  - Efficiency as a negative cost or profitable investment
  - Renewables as costing > 0
- Two properties of these Supply Curves
  1. The shaded areas are proportional to annualized savings or costs -- the graph shows that efficiency (area below x-axis) saves about $50 Billion per year and nearly pays for the renewables (area above x-axis)

     The ratio is about 40:60
  2. The Simple Payback Time (SPT) can be estimated directly from the graph, if we know the service life of the investment

McKinsey Quarterly

A **cost curve** for greenhouse gas reduction

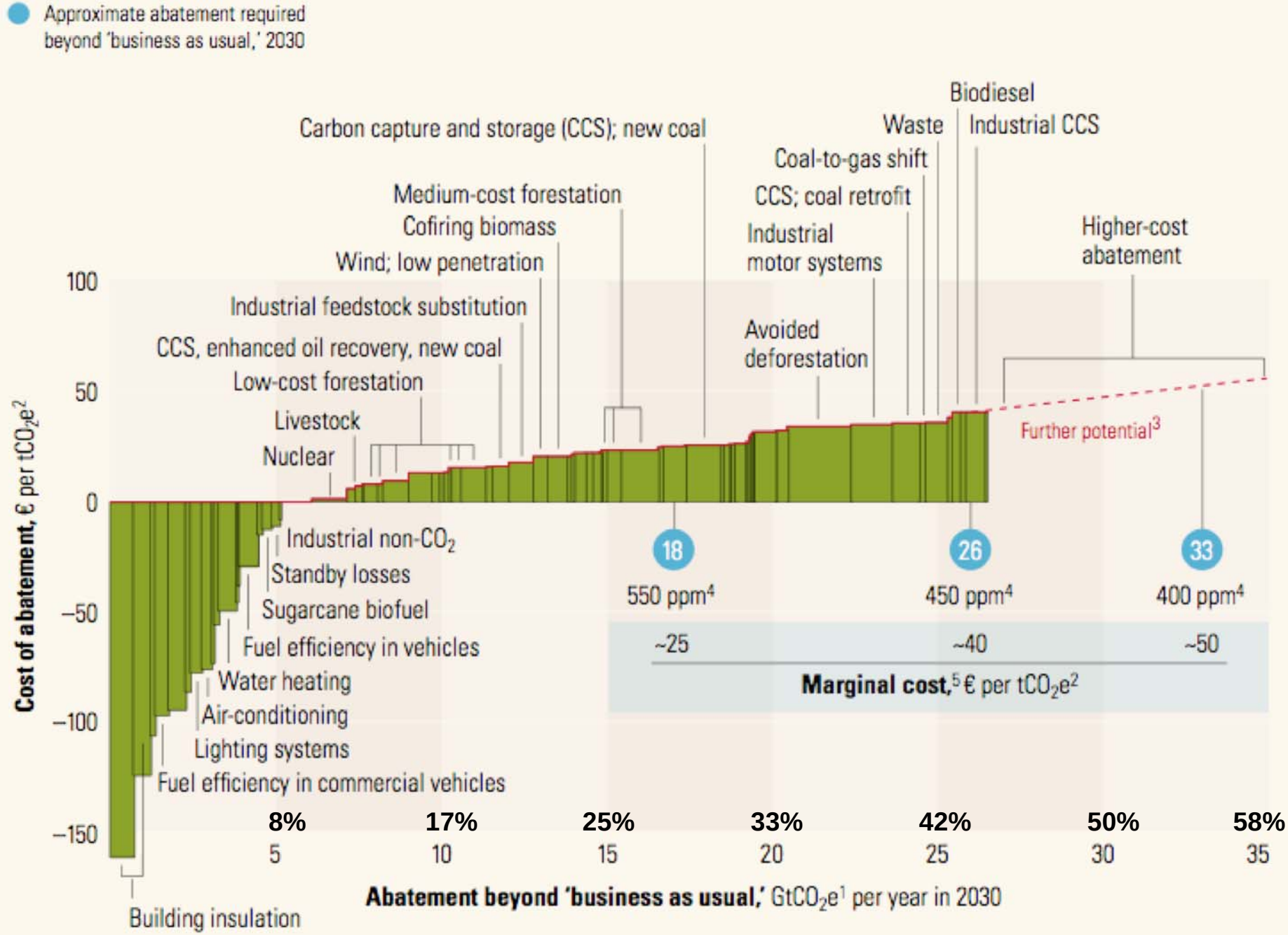
With a Worldwide Perspective

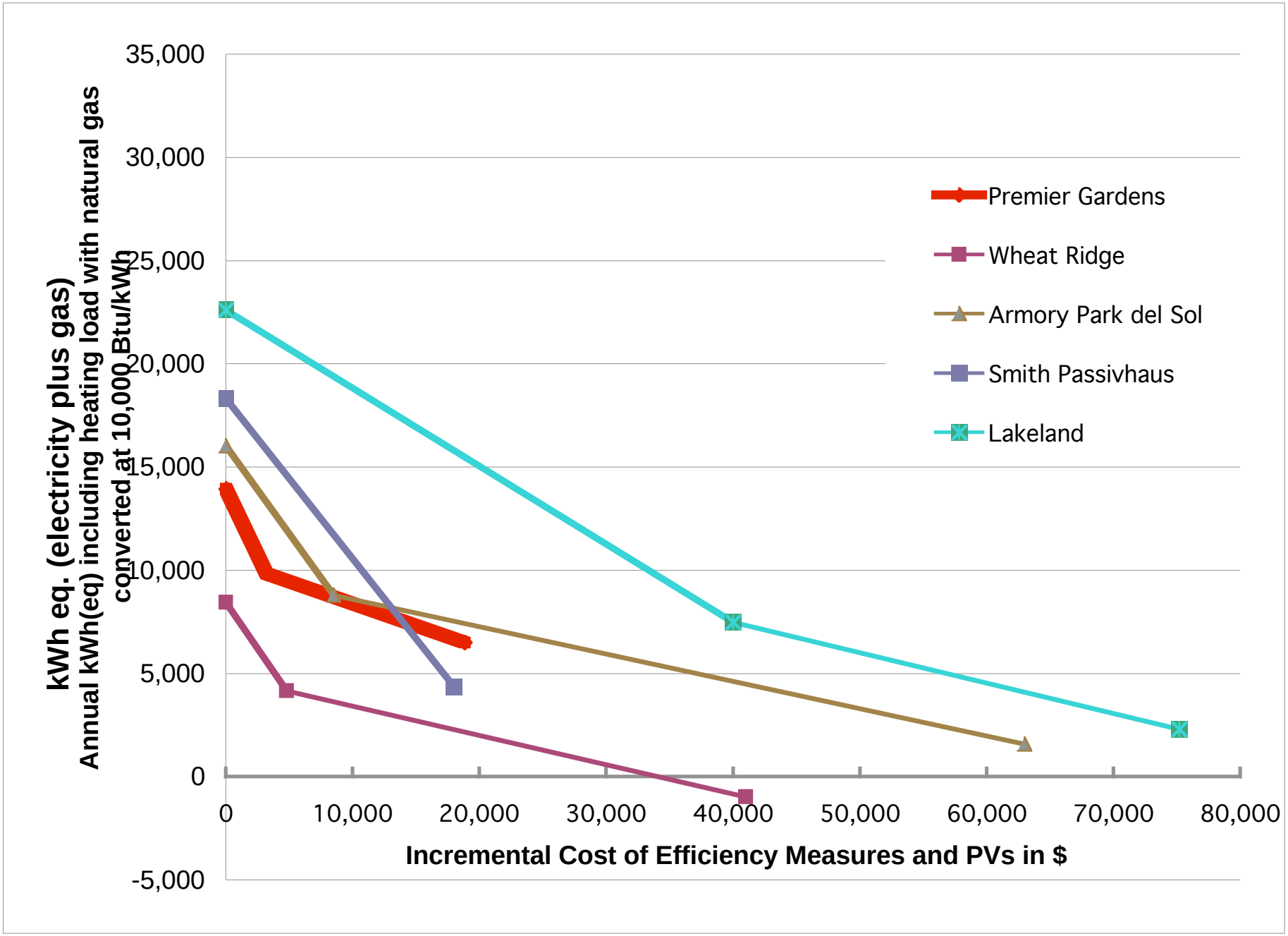
A global study of the size and cost of measures to reduce greenhouse gas emissions yields important insights for businesses and policy makers.

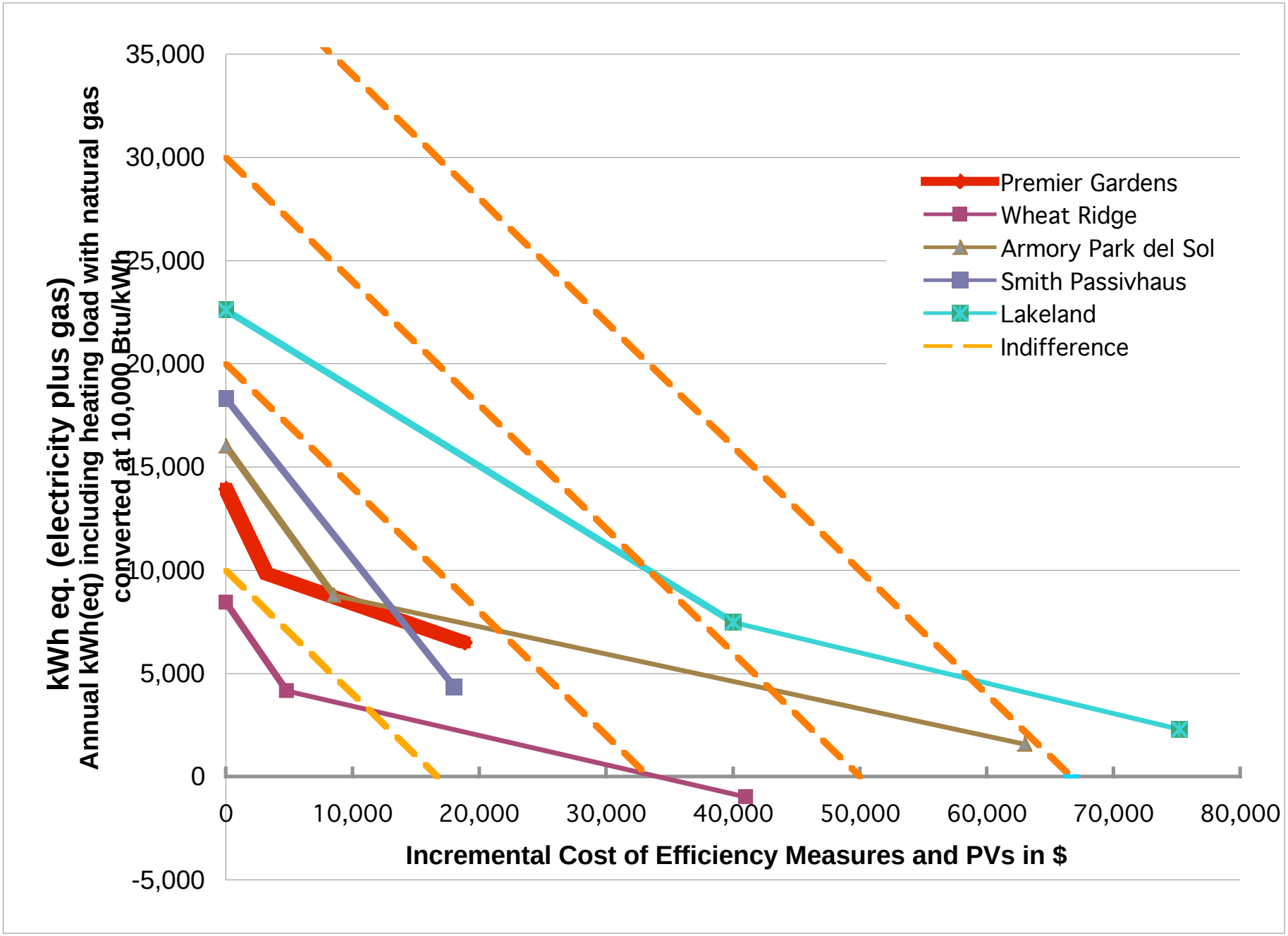
Per-Anders Enkvist, Tomas Nauclér, and Jerker Rosander

http://www.mckinseyquarterly.com/Energy_Resources_Materials/A_cost_curve_for_greenhouse_gas_reduction_abstract

Global cost curve for greenhouse gas abatement measures beyond 'business as usual'; greenhouse gases measured in $GtCO_2e$[1]




kWh eq. (electricity plus gas)
Annual kWh(eq) including heating load with natural gas converted at 10,000 Btu/kWh
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
-5,000
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
Incremental Cost of Efficiency Measures and PVs in $
Premier Gardens
Wheat Ridge
Armory Park del Sol
Smith Passivhaus
Lakeland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35,000
30,000
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10,000
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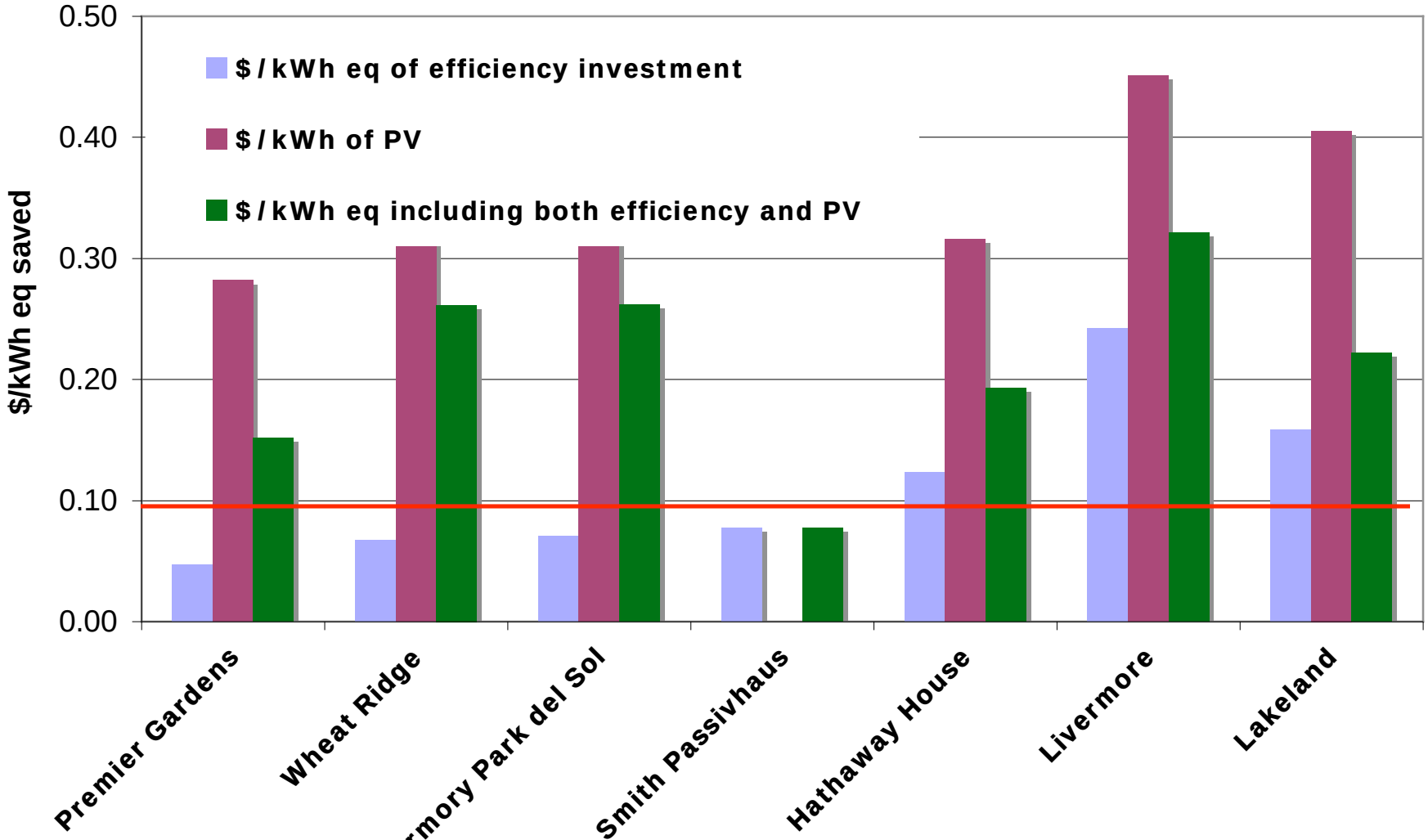
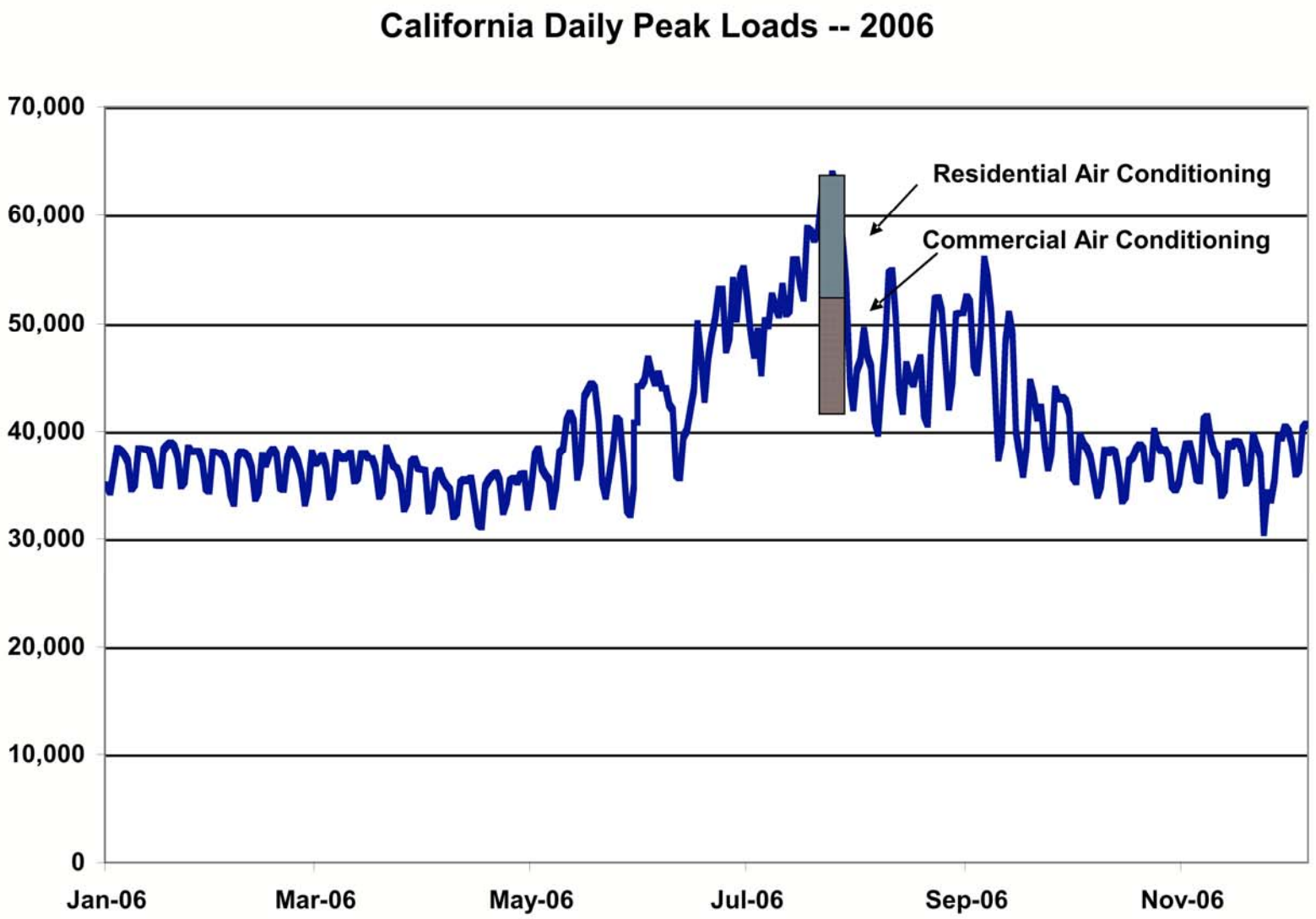
30,000
40,000
50,000
60,000
70,000
80,000
Incremental Cost of Efficiency Measures and PVs in $
Premier Gardens
Wheat Ridge
Armory Park del Sol
Smith Passivhaus
Lakeland
Indifference


0.50
0.40
0.30
0.20
0.10
0.00
$/kWh eq saved
$ / kWh eq of efficiency investment
$ / kWh of PV
$ / kWh eq including both efficiency and PV
Premier Gardens
Wheat Ridge
Armory Park del Sol
Smith Passivhaus
Hathaway House
Livermore
Lakeland

Part 3 – Demand Response

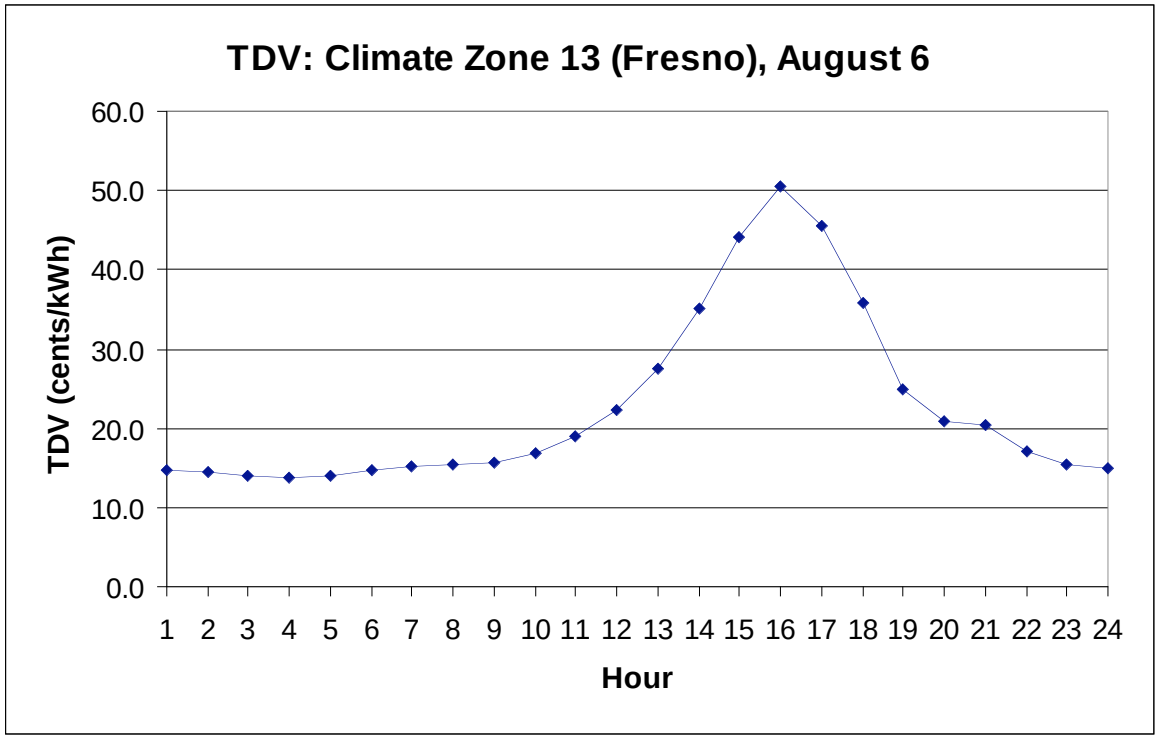
- Thermal Mass
- Thermal Storage
- Operable Shutters
- Cool Roofs

California is VERY MUCH a Summer Peaking Area



Time dependent valuation (TDV) prices are also used to calculate bills

- TDV prices are incorporated into California appliance standards (Title 20) and building standards (Title 24)
- TDV prices, or avoided costs, are independent of the idiosyncrasies of utility tariffs
- TDV prices incent efficient air conditioners

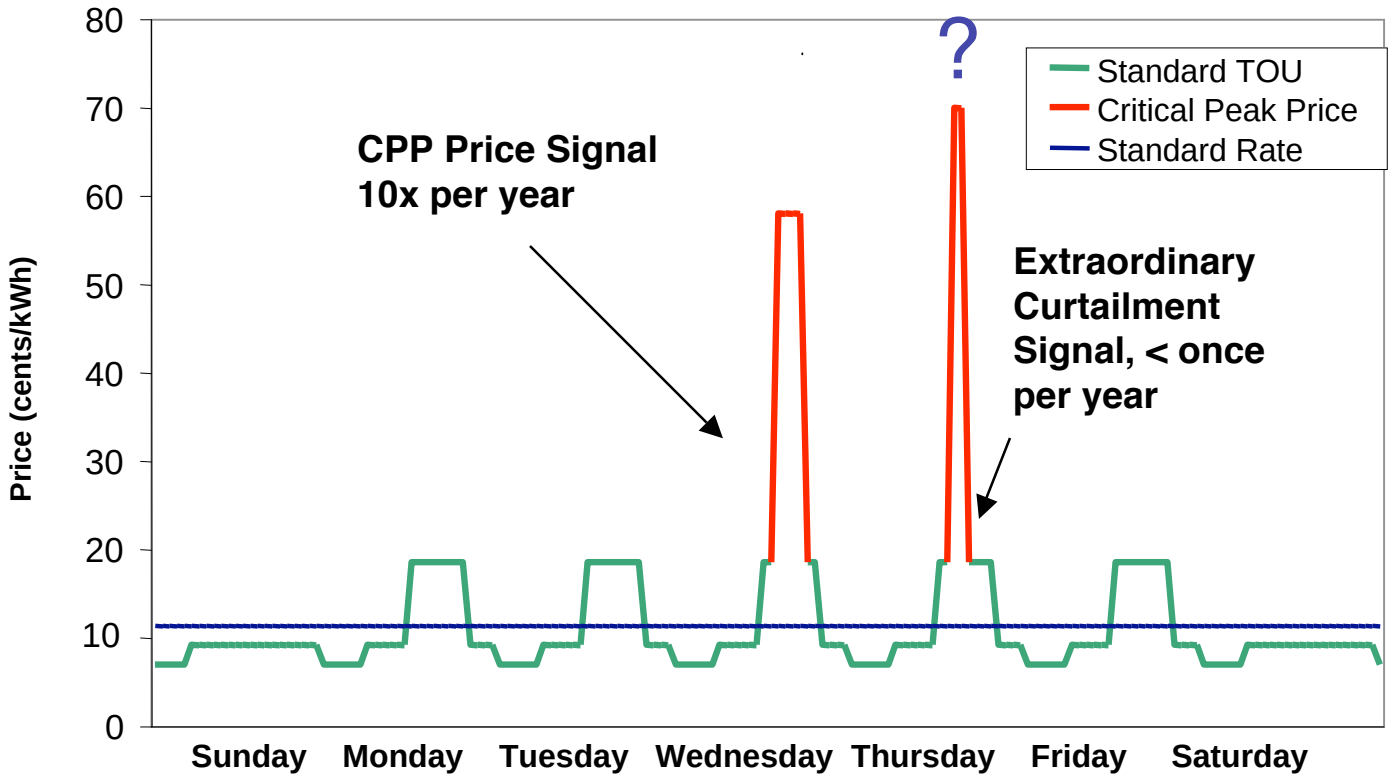


Demand Response and Advanced Metering Infrastructure

- Began 6 years ago during California electricity crisis
  - All large customers (>200kW) received digital meters and were required to move to Time-of-Use rates
- In 2003, we established a Goal of 5% price responsive demand by 2007
- We have been testing the demand response of “CPP” (Critical Peak Pricing, which is the California version of French “Tempo”)
- Results for residential customers
  - 12% reduction when faced with critical peak prices and no technology
  - 30% to 40% reduction for customers with air conditioning, technology, and a critical peak price.
- For larger customers, the Demand Response Research Center at Lawrence Berkeley National Lab has been testing Automated Demand Response with the same type of “CPP” tariff
  - Customer Response in the range of 12% during events
  - And response is “pre-programmed” and can be automatic
    - Highly customer specific (process load, lighting, HVAC)

Critical Peak Pricing (CPP)
with additional curtailment option

Potential Annual Customer Savings:
10 afternoons x 4 hours x 1kw = 40 kWh at 70 cents/kWh = ~$30/year

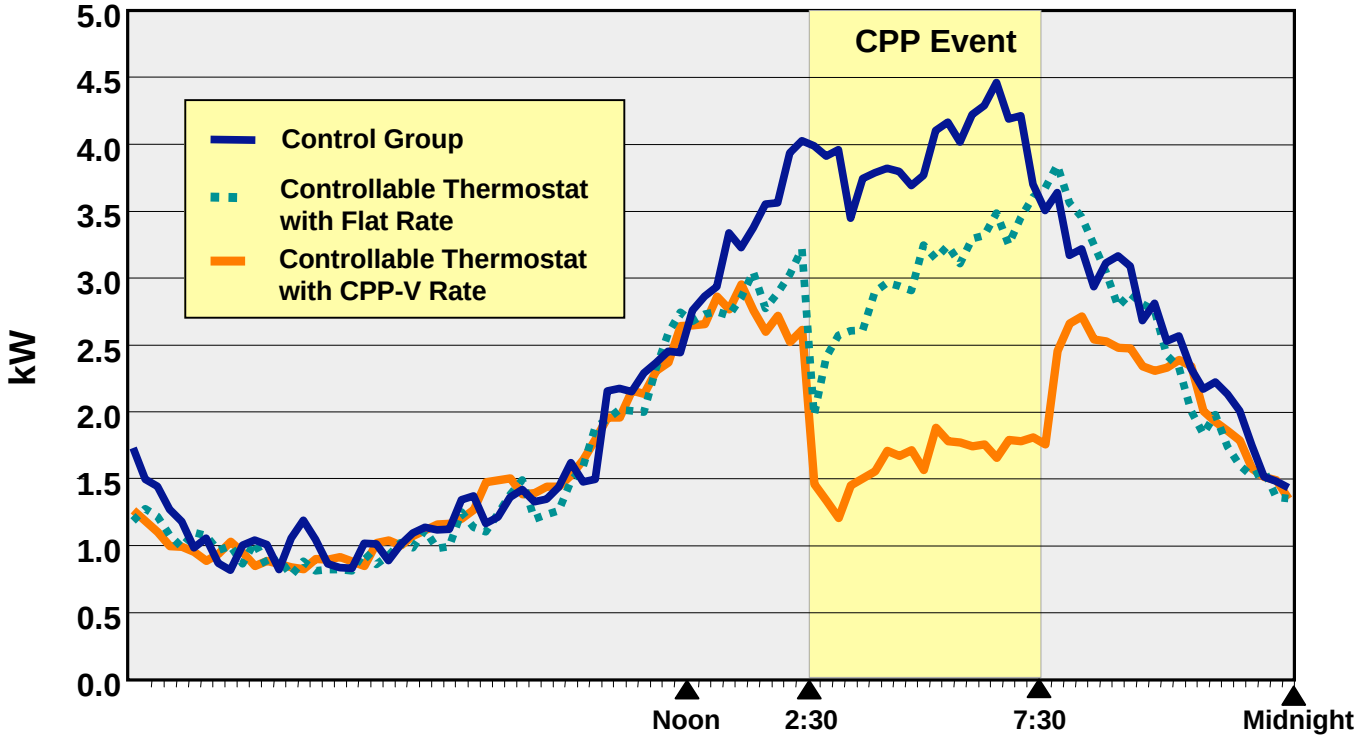


CPP rates – Load Impacts

Residential Response on a typical hot day

Control vs. Flat rate vs. CPP-V Rate

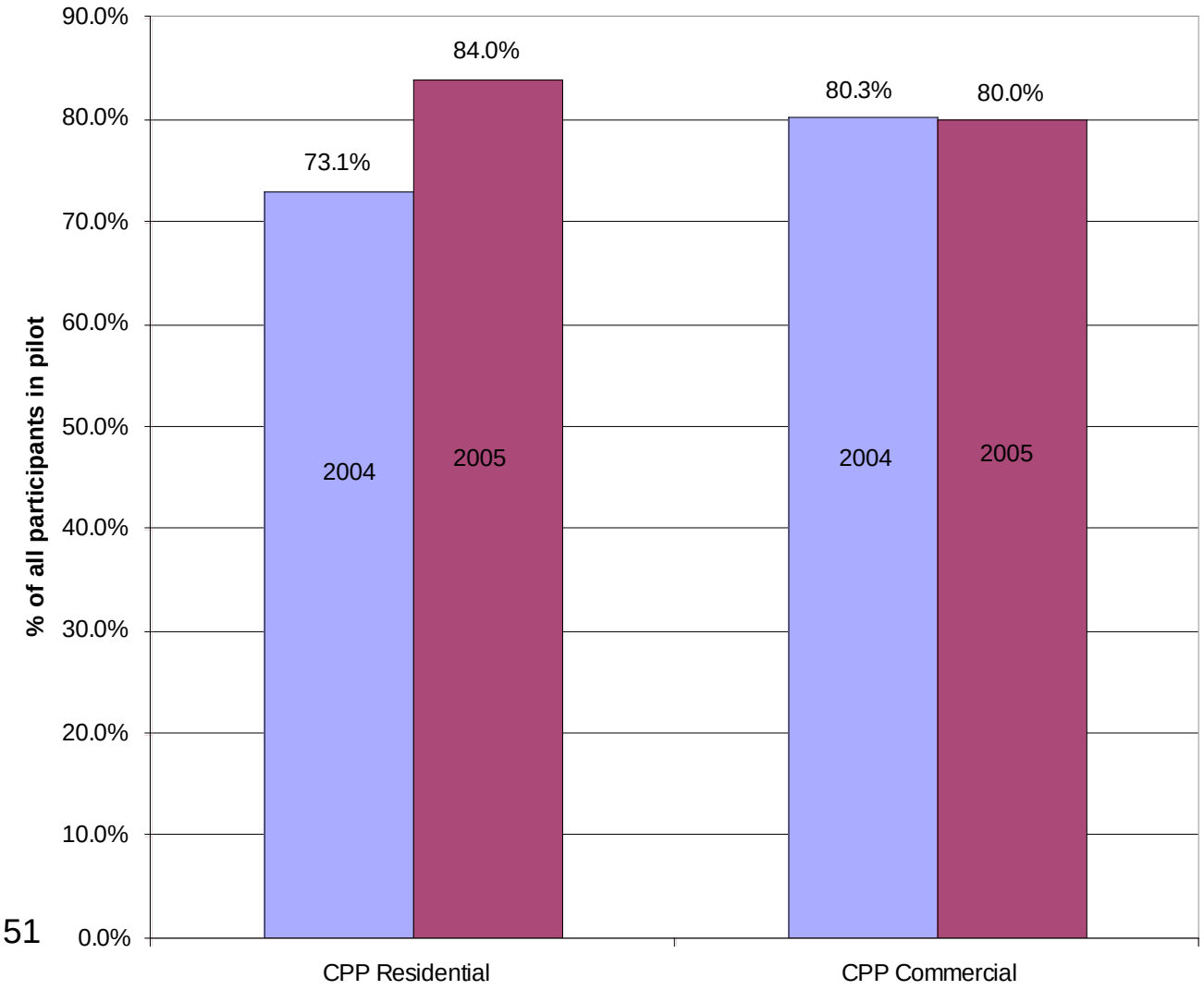
(Hot Day, August 15, 2003, Average Peak Temperature 88.5^0)



Most customers (~ 80%) Saved Money and Most (~60%) thought all customers should be offered this type of rate.

Source: Response of Residential Customers to Critical Peak Pricing and Time-of-Use Rates during the Summer of 2003, September 13, 2004, CEC Report.

Fraction of Customers on CPP Rates with Lower bills in 2004 and 2005- Residential and Small Commercial



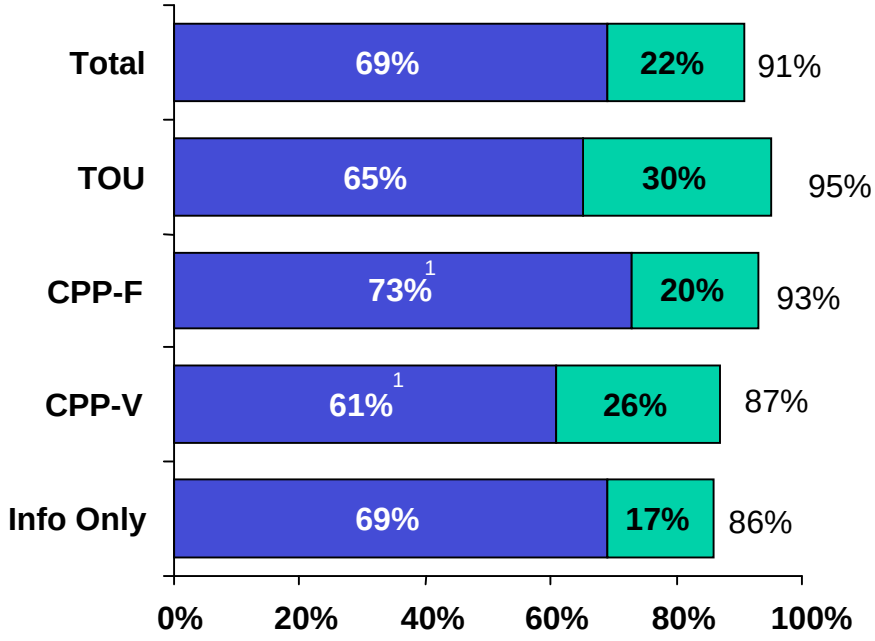
Average residential savings= $38/year

Average small commercial savings-$1300/yr

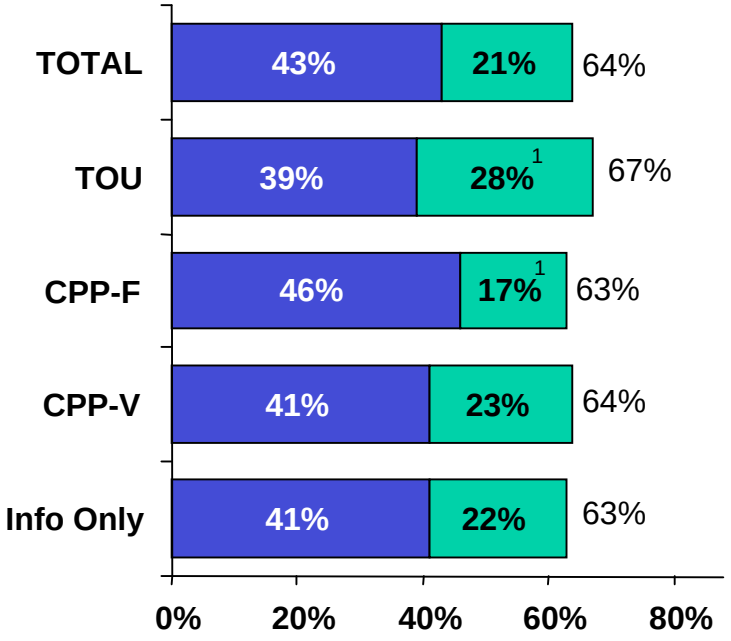
Customer Acceptance of CPP rates

Residential participants express a strong interest in having dynamic rates offered to all customers.

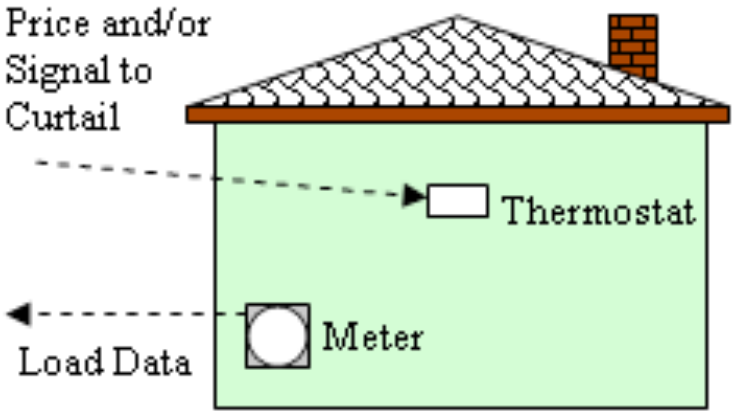
Should dynamic rates be offered to all customers?



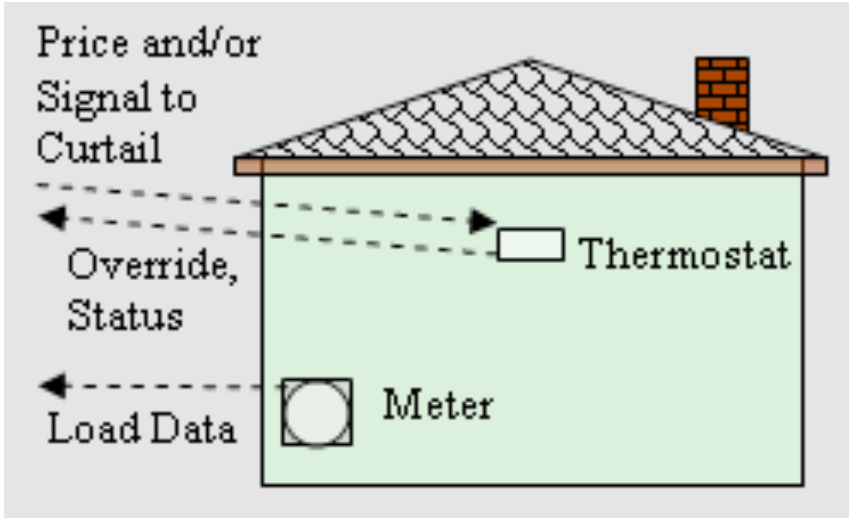
Should all customers be placed on a dynamic rate and given an option to switch to another rate?

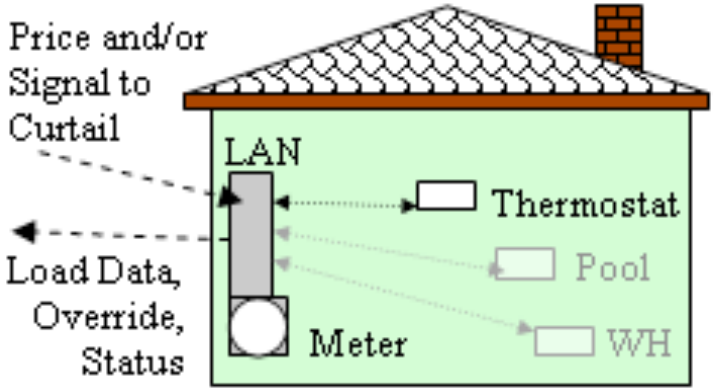


Source: Statewide Pricing Pilot: End-of-Pilot Customer Assessment, December 2004, Momentum Market Intelligence.



Just some of the proposed systems for PCTs and demand response in the residential and small commercial/industrial sectors.

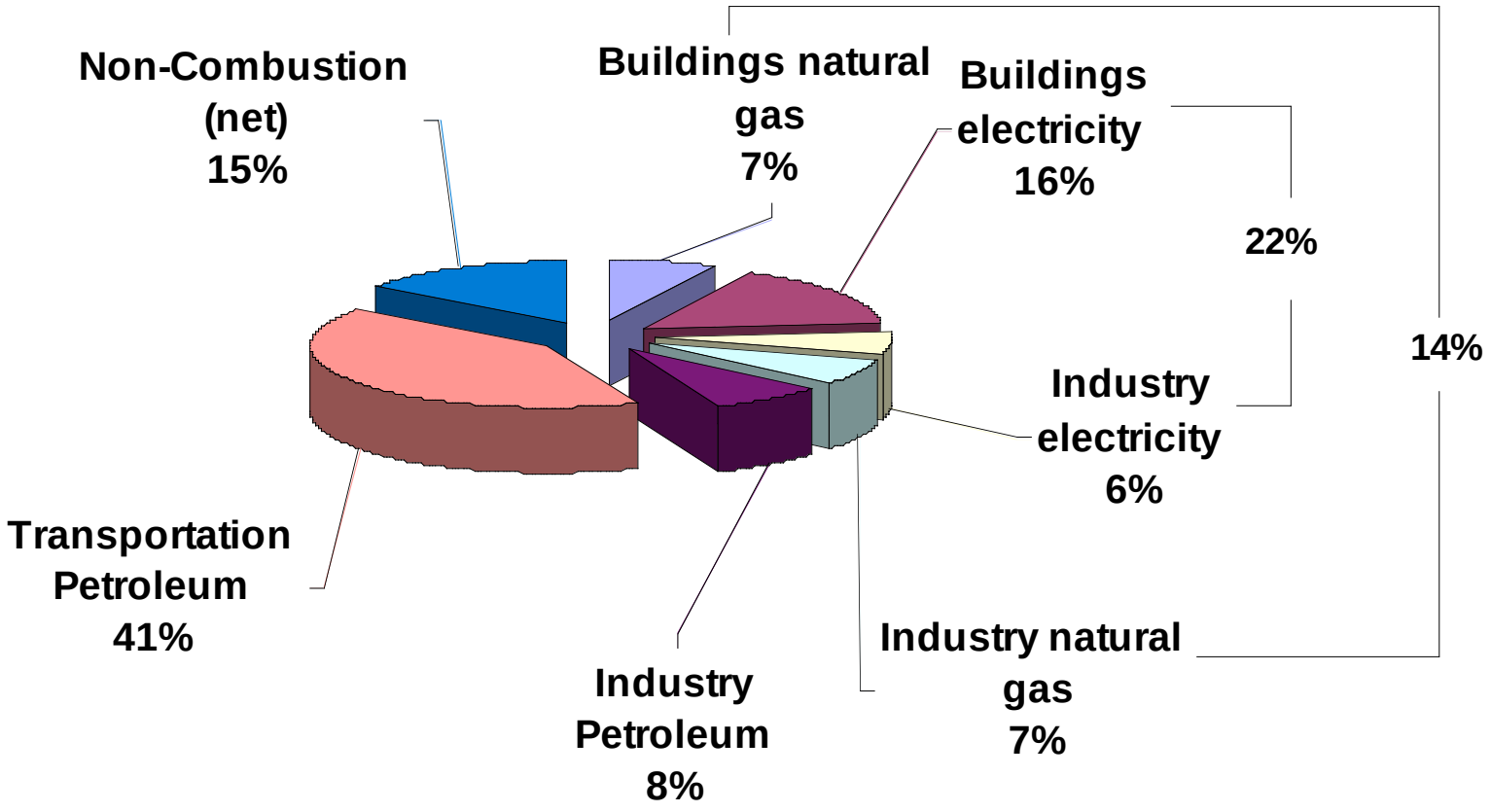




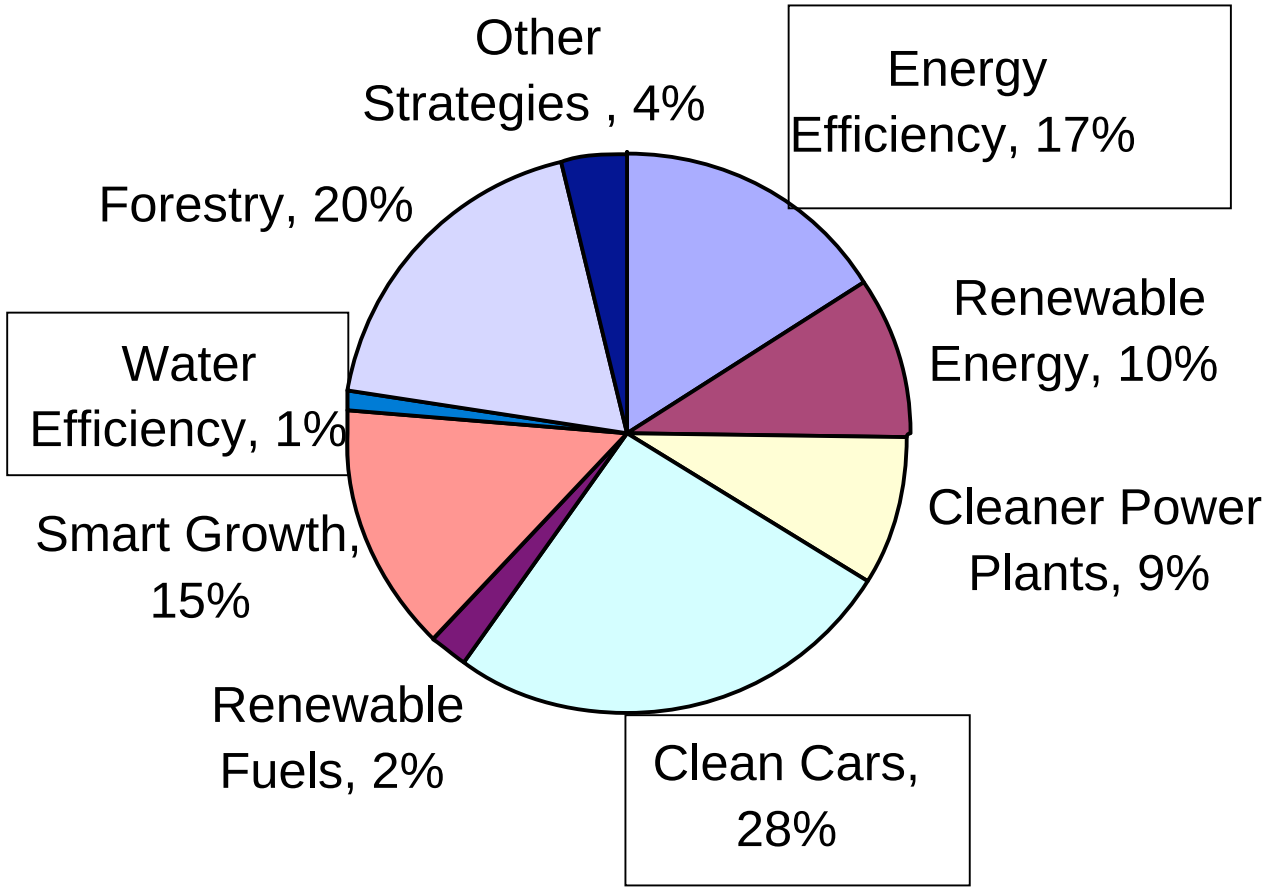
Part 4
California Greenhouse Reduction Goals: AB 32


The Economist
Shake-up in Big Pharma
China's space blast
Europe's rotating slump
Serbia's encouraging election
Hating Hillary Clinton
The greening of America
And California

Emissions of CO2 in California by End Use in 2004
Total Emissions = 490 Million metric tons CO2 equivalent



Strategies for Meeting California's CO2 Goals in 2020
Total Reductions = 174 Million metric Tons CO2 equivalent



Governor Schwarzenegger's and California's Efforts

June 2005 Executive Order on Climate Change

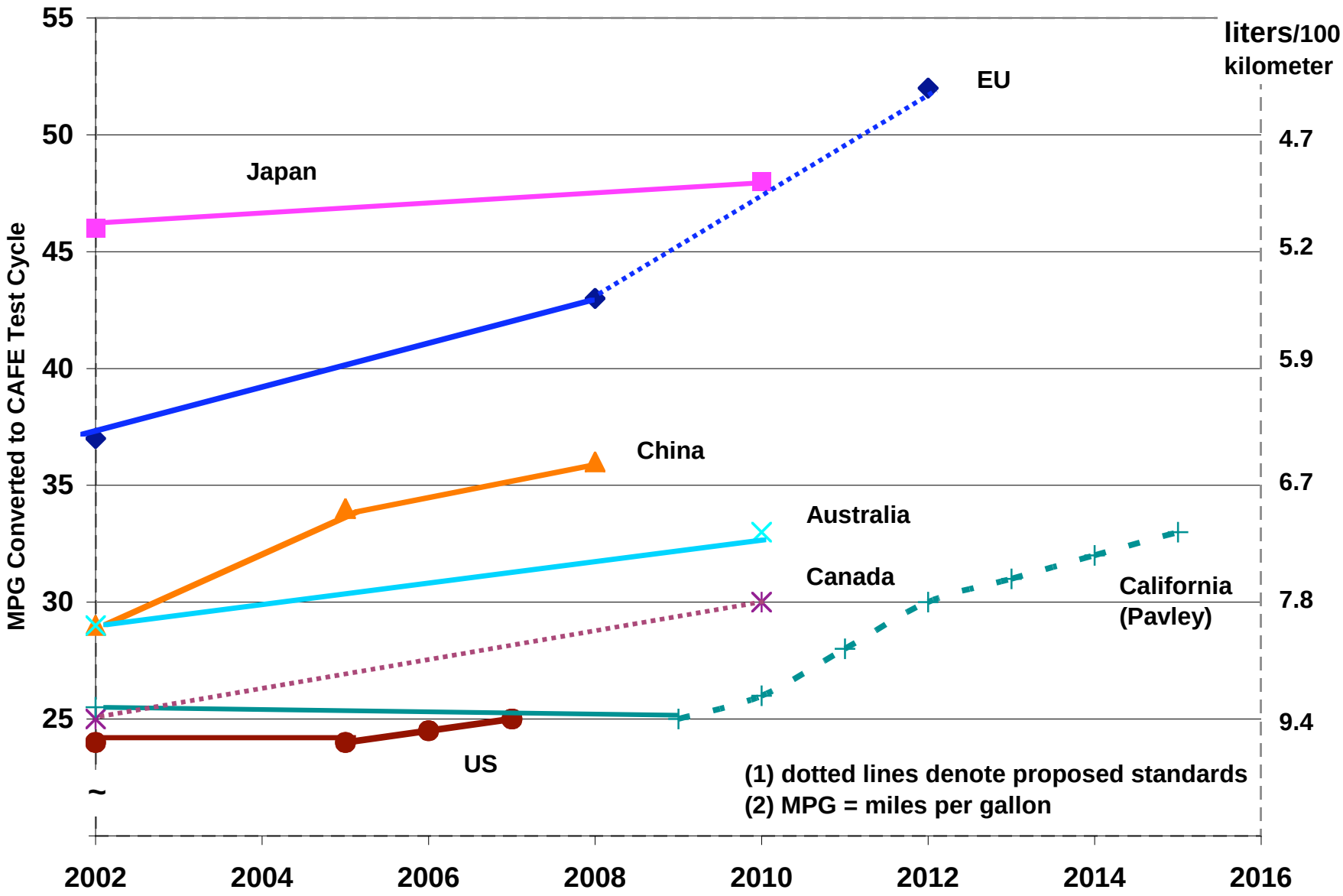
- Reduce greenhouse gases:
  - to 2000 levels by 2010
  - to 1990 levels by 2020 (~30% below BAU!!)
  - to 80 percent below 1990 levels by 2050

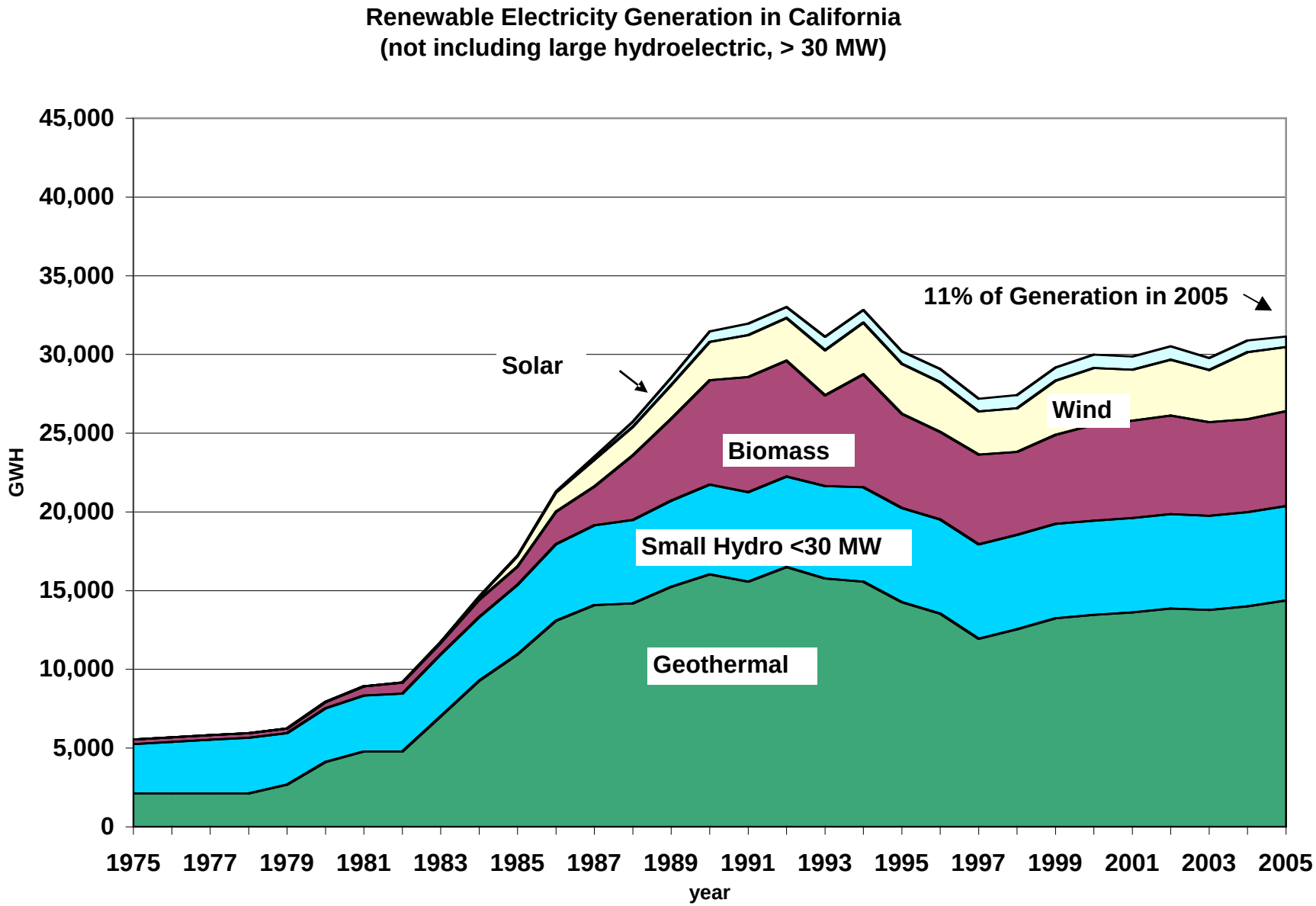
AB 32 – the Global Warming Solutions Act of 2006

- Confirms the Governor's Executive Order
- Adopt regulations to achieve maximum feasible and cost-effective GHG reductions
- Adopt market mechanisms, such as cap and trade
- Establish mandatory reporting of GHG emissions by major industries
- Adopt a statewide GHG emissions limit for 2020 matching 1990 emissions

www.ClimateChange.ca.gov

Comparison of Fuel Economy – Passenger Vehicles




Renewable Electricity Generation in California
(not including large hydroelectric, > 30 MW)
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
GWH
11% of Generation in 2005
Solar
Wind
Biomass
Small Hydro <30 MW
Geothermal
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
year